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Deuel et al.

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(45) **Date of Patent: Jul. 14, 2015**

(54) **DISPLAY AND USER INTERFACE**

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PCT Pub. Date: **Jun. 19, 2008**

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G06F 3/042 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 3/0421*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/042; G06F 3/0421
USPC 345/173, 175
See application file for complete search history.

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Primary Examiner — Lixi C Simpson
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A touchless method for registering commands from a display (e.g. reconfigurable display) may include any of various components. The method may use a light sensor in front of or behind the display to detect light reflected by a user's finger approaching a control option displayed on the display. Light used to display images may be provided at a frequency and/or time that can be identified by a processor connected to the light sensor, or can possess some other unique property (e.g. color) which may be distinguished by the processor.

45 Claims, 15 Drawing Sheets

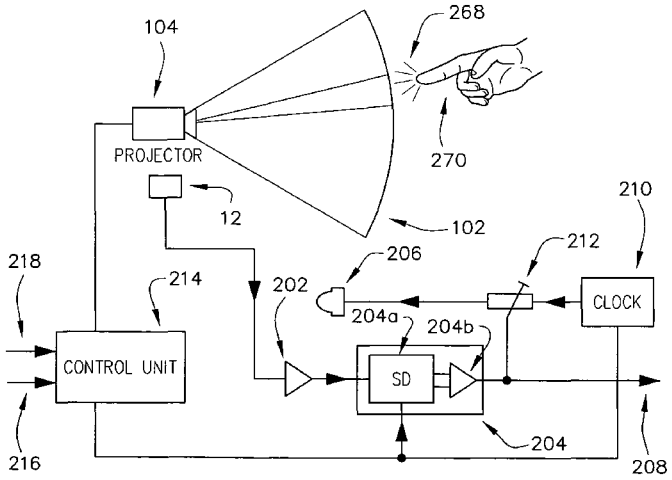

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FIG. 1

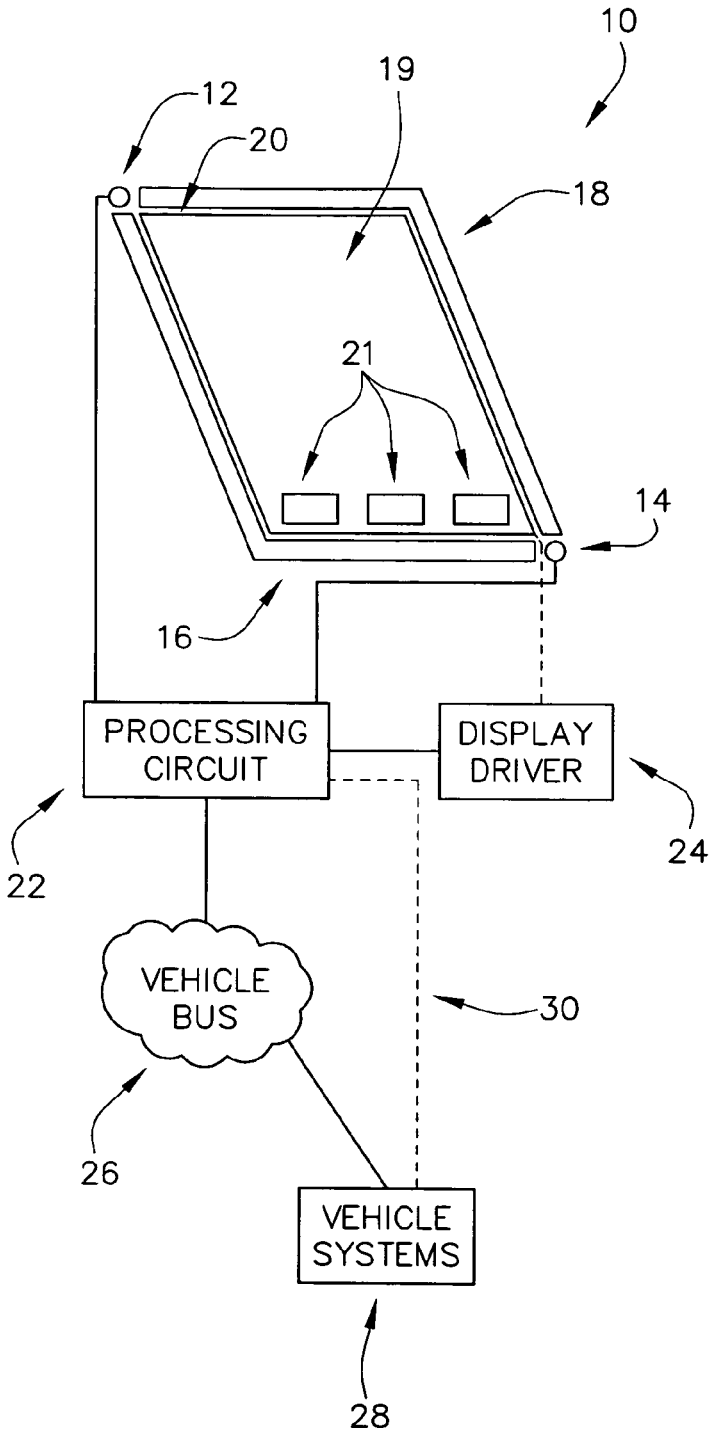

10
19
12
20
18
21
14
16
PROCESSING CIRCUIT
DISPLAY DRIVER
22
24
VEHICLE BUS
30
26
VEHICLE SYSTEMS
28

FIG. 2

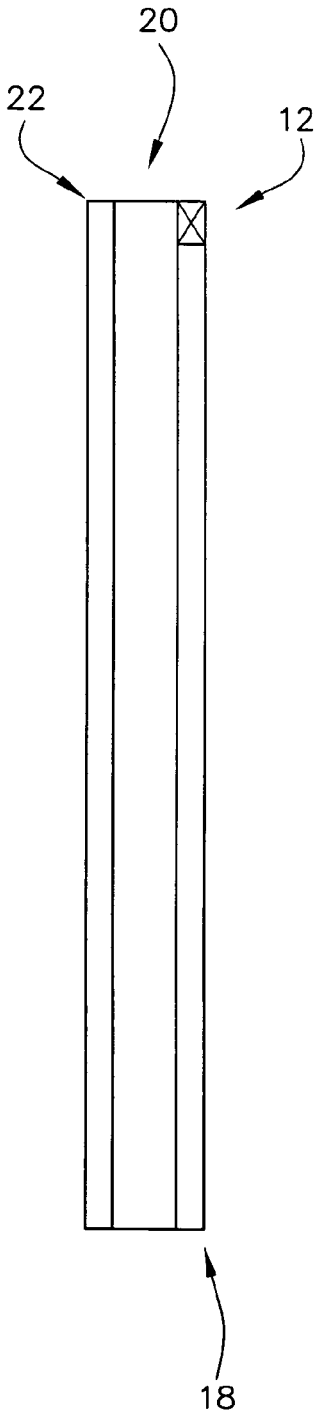

20
22
12
18

FIG. 3

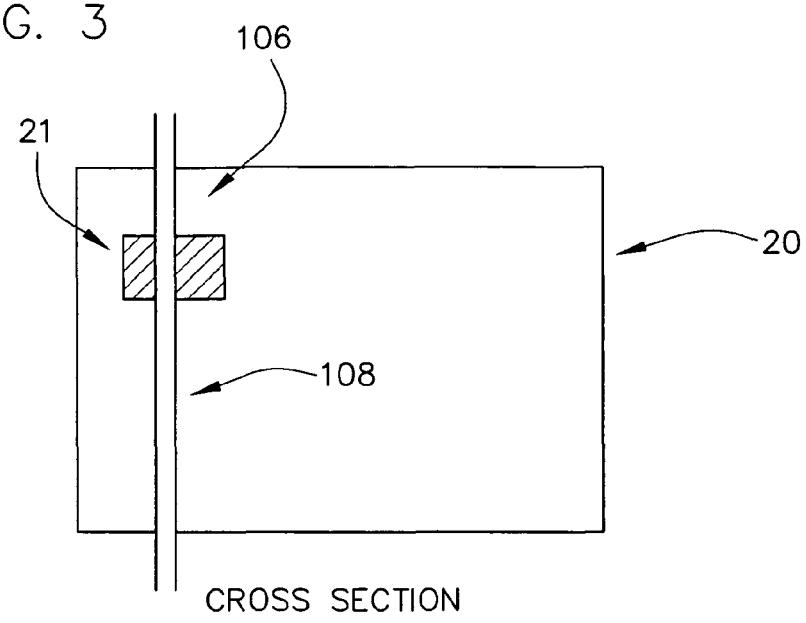

106
21
20
108
CROSS SECTION

FIG. 4

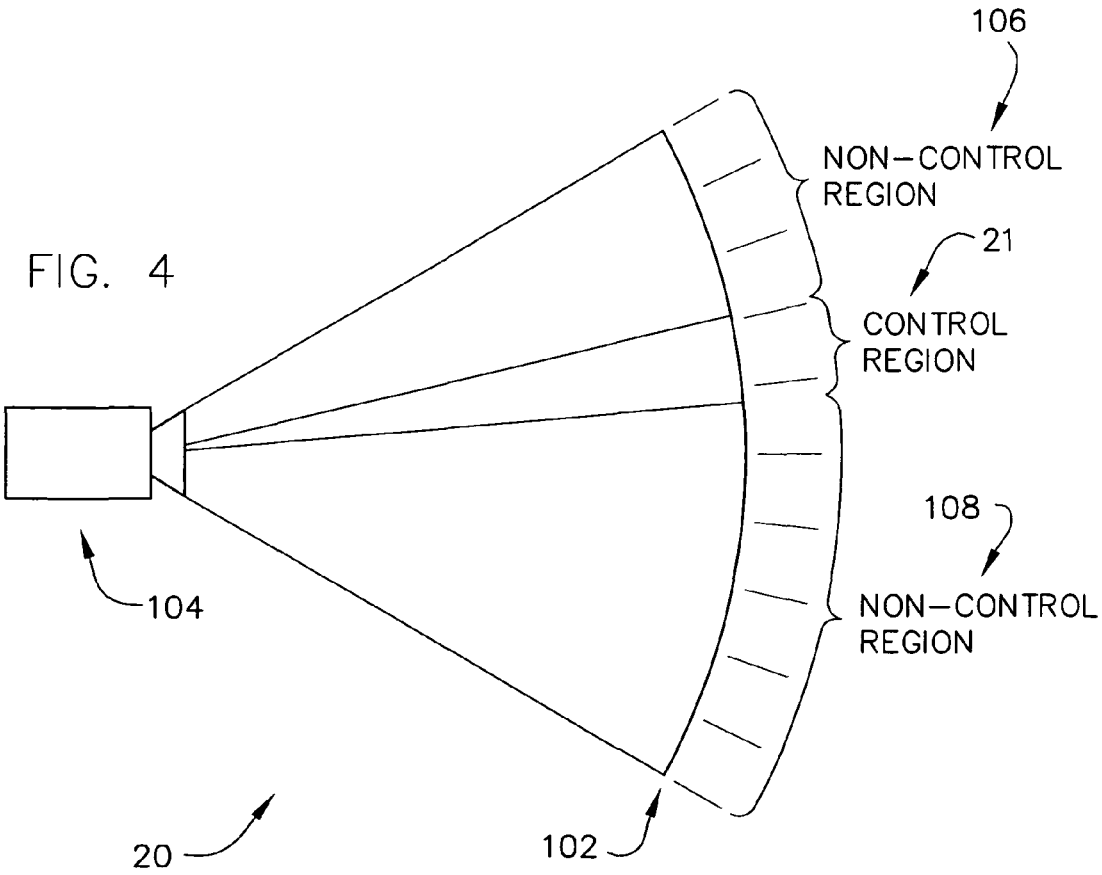

106
NON-CONTROL REGION
21
CONTROL REGION
108
NON-CONTROL REGION
104
20
102

FIG. 5

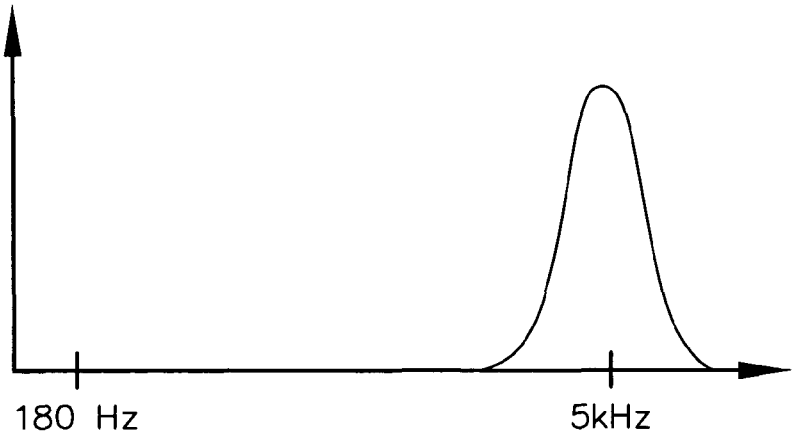


FIG. 6

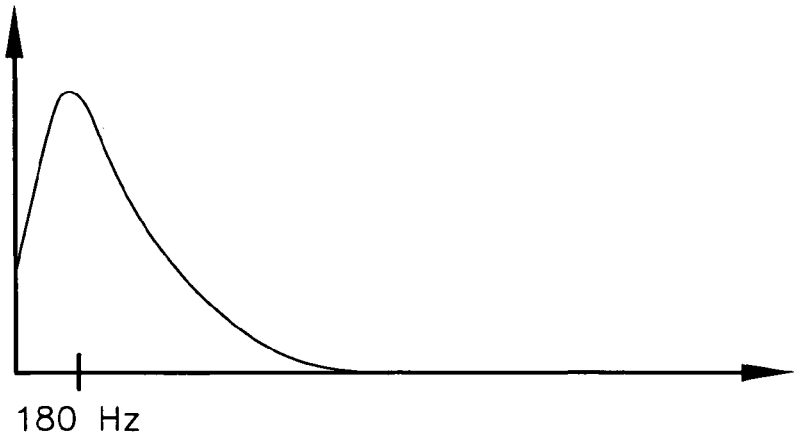


FIG. 7

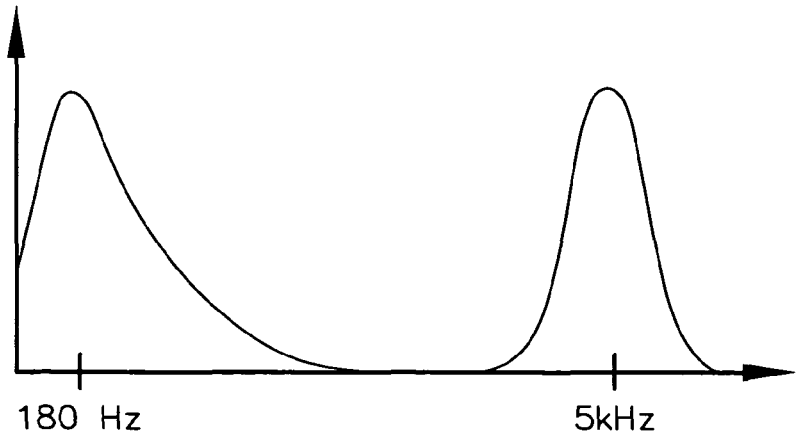
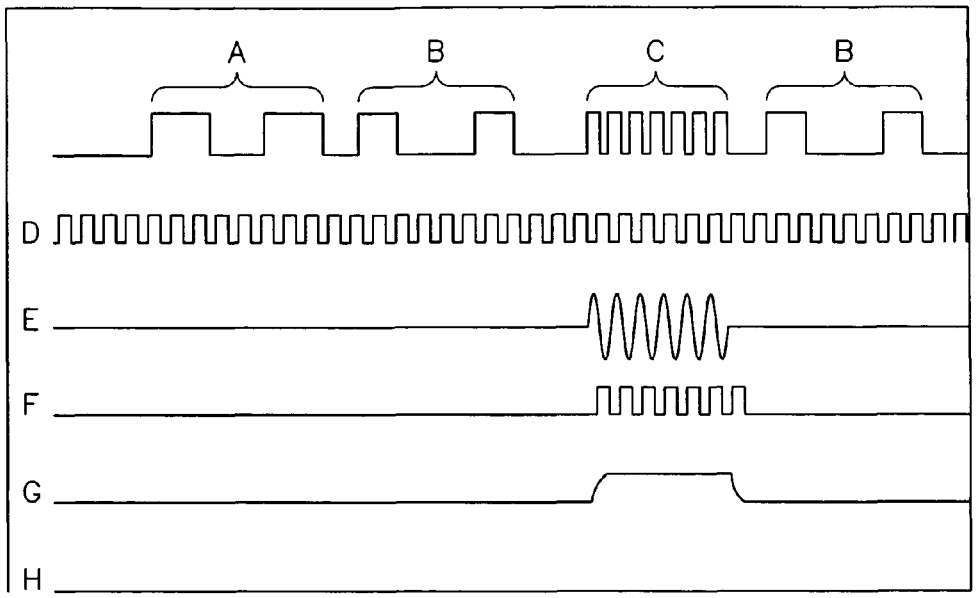


FIG. 8


A
B
C
B
D
E
F
G
H

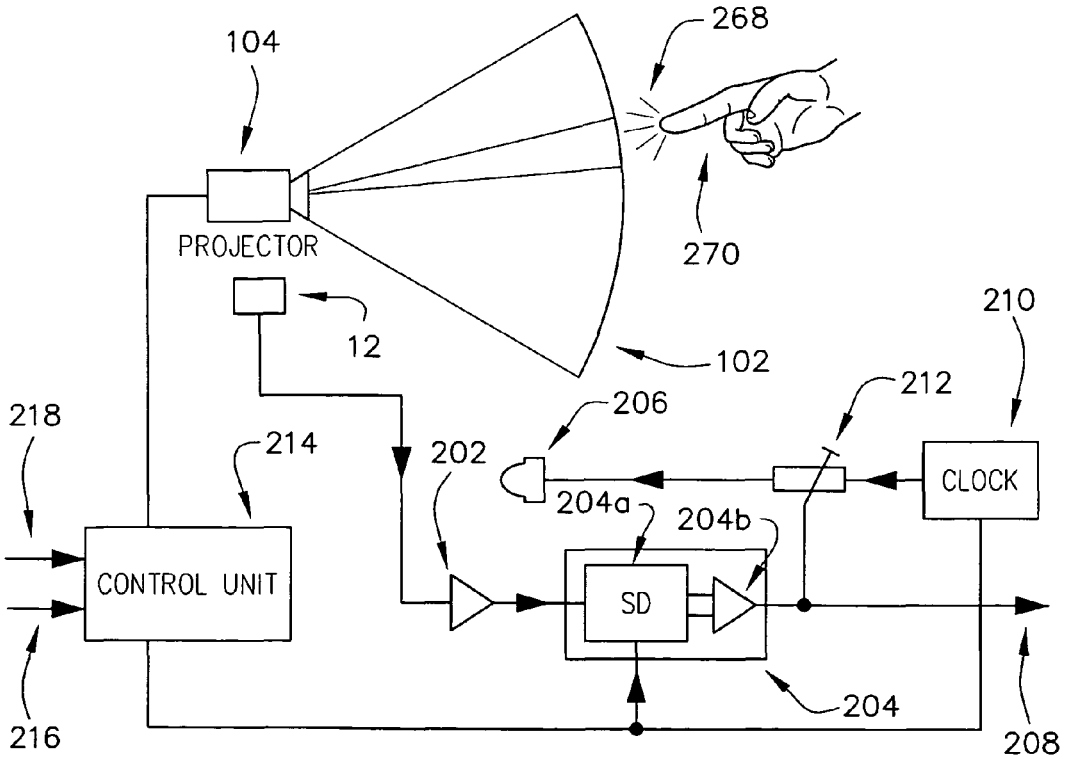

104
268
PROJECTOR
270
12
102
210
212
206
218
214
202
CLOCK
204a
204b
CONTROL UNIT
SD
204
216
208

FIG. 9

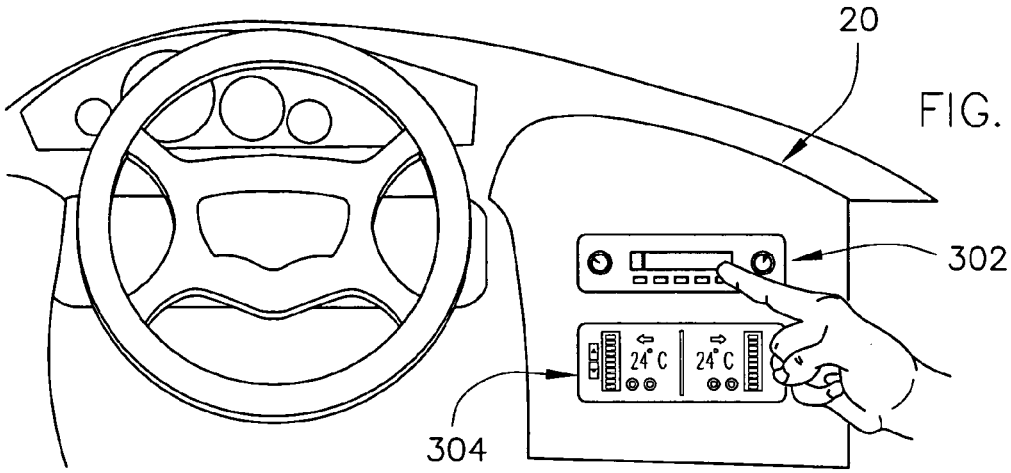


FIG. 10

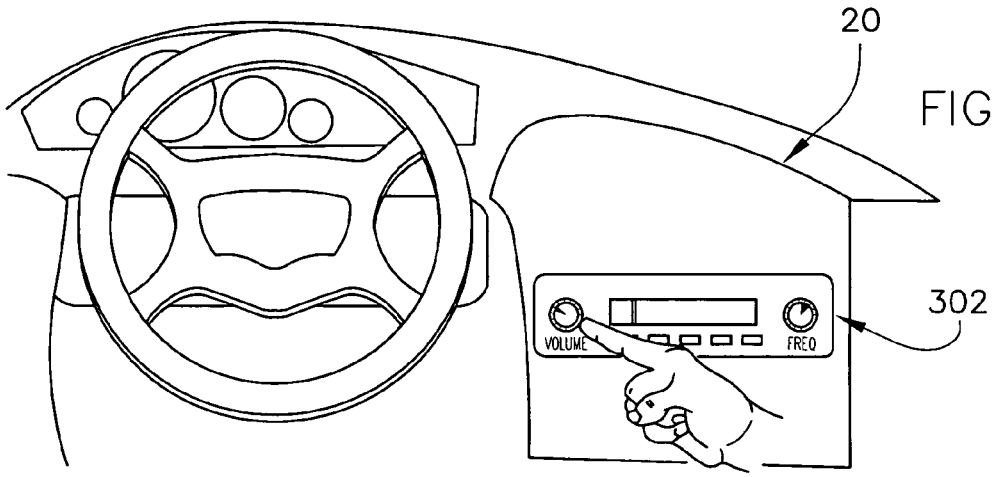


FIG. 11

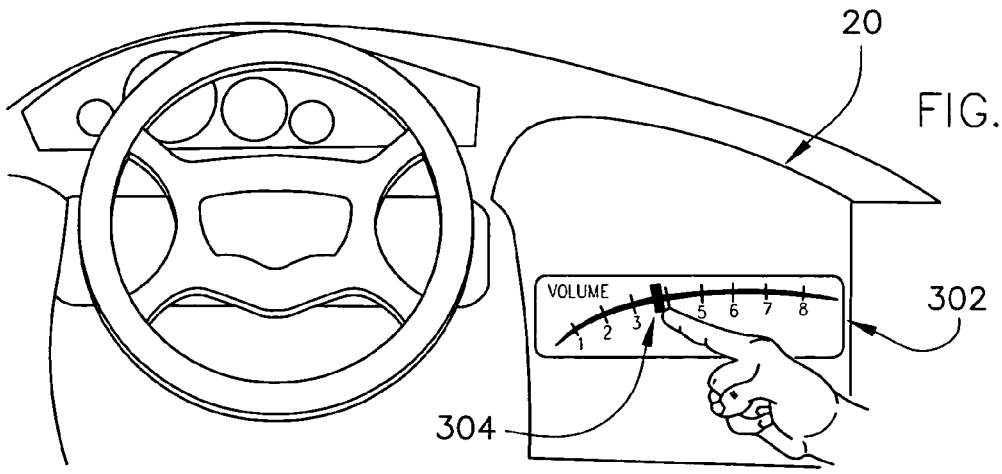


FIG. 12

FIG. 13

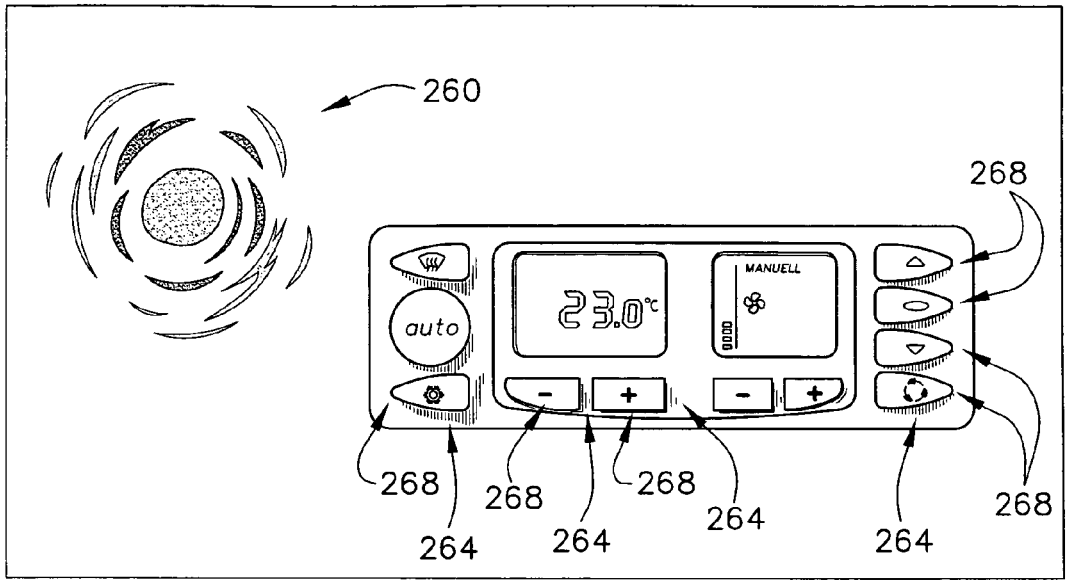

260
268
auto
23.0°c
MANUELL
268
268
268
264
264
264
264
268

FIG. 14

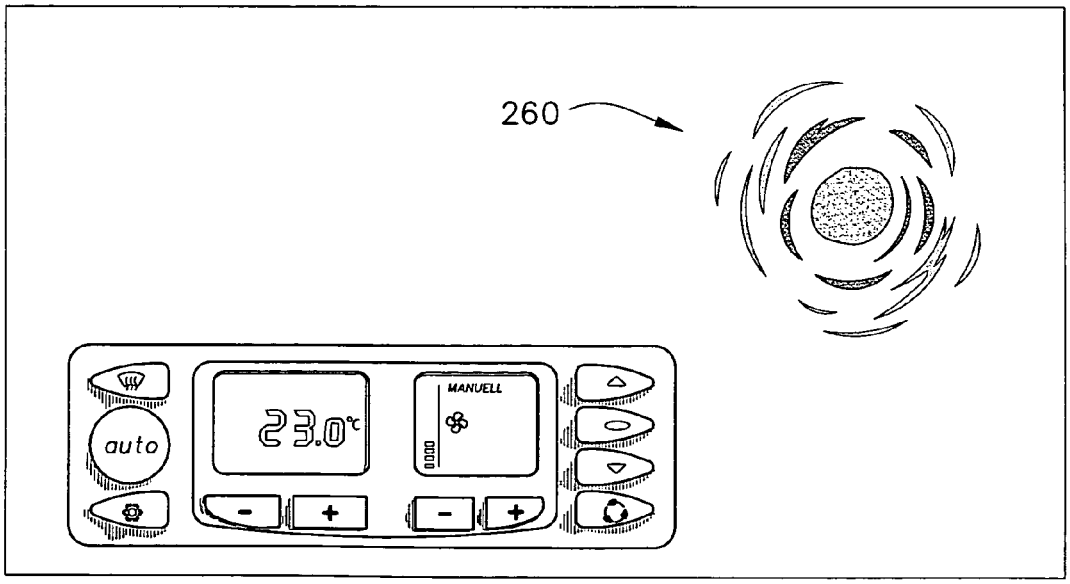

260
auto
23.0°c
MANUELL

FIG. 15

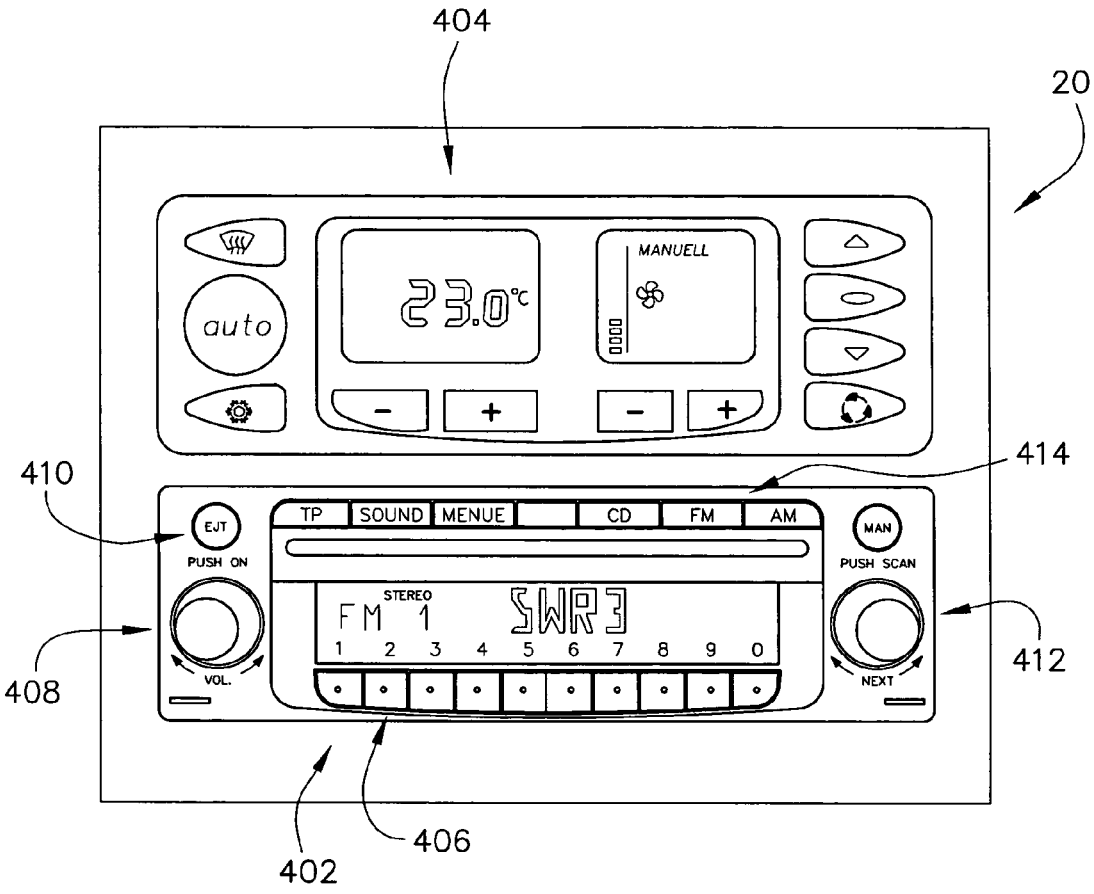

404
20
auto
23.0°C
MANUELL
414
410
EJT
PUSH ON
TP
SOUND
MENUE
CD
FM
AM
MAN
PUSH SCAN
STEREO
FM 1
SWR3
1 2 3 4 5 6 7 8 9 0
VOL.
NEXT
408
412
402
406

FIG. 16

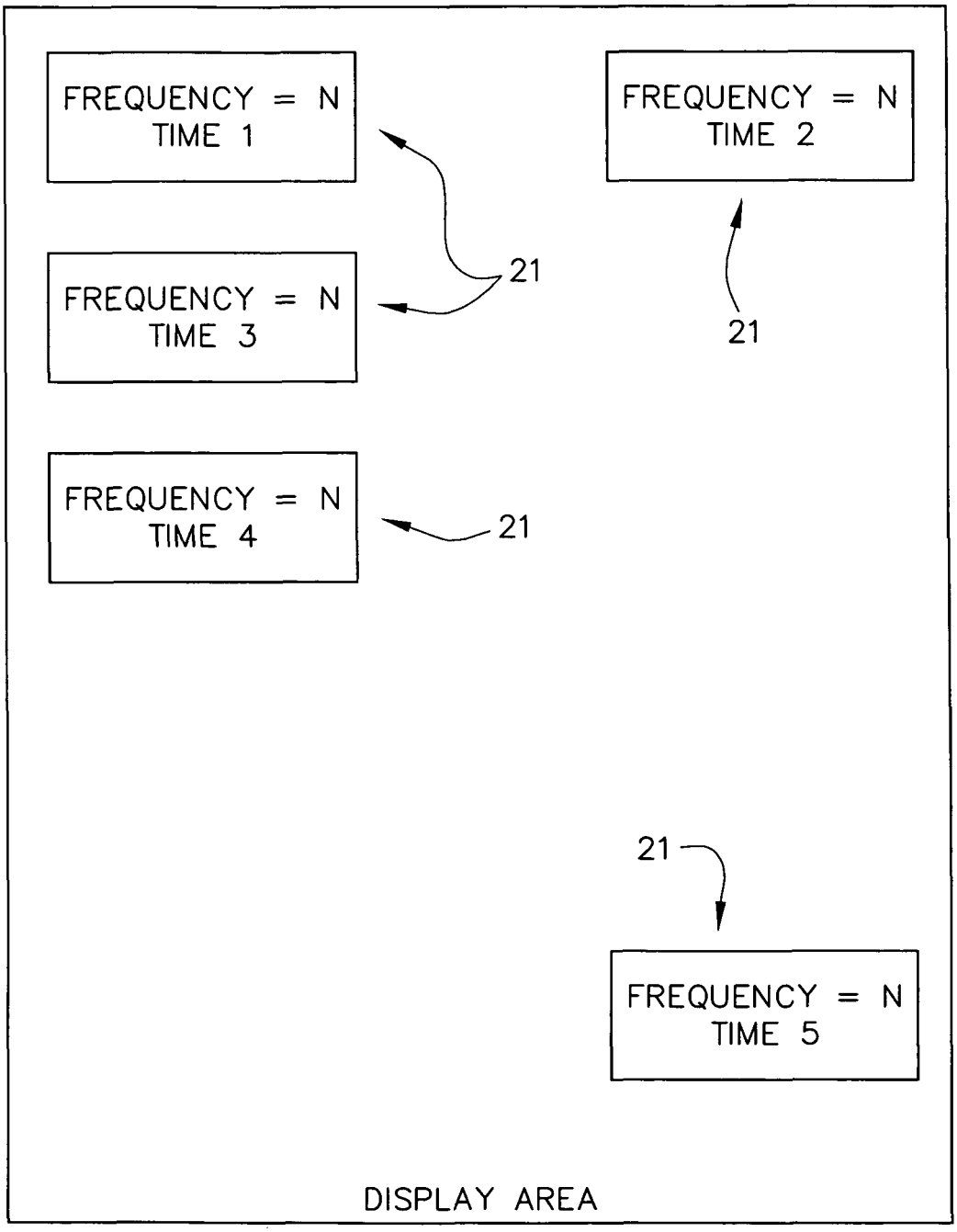

FREQUENCY = N
TIME 1
FREQUENCY = N
TIME 2
FREQUENCY = N
TIME 3
21
21
FREQUENCY = N
TIME 4
21
21
FREQUENCY = N
TIME 5
DISPLAY AREA

FIG. 17

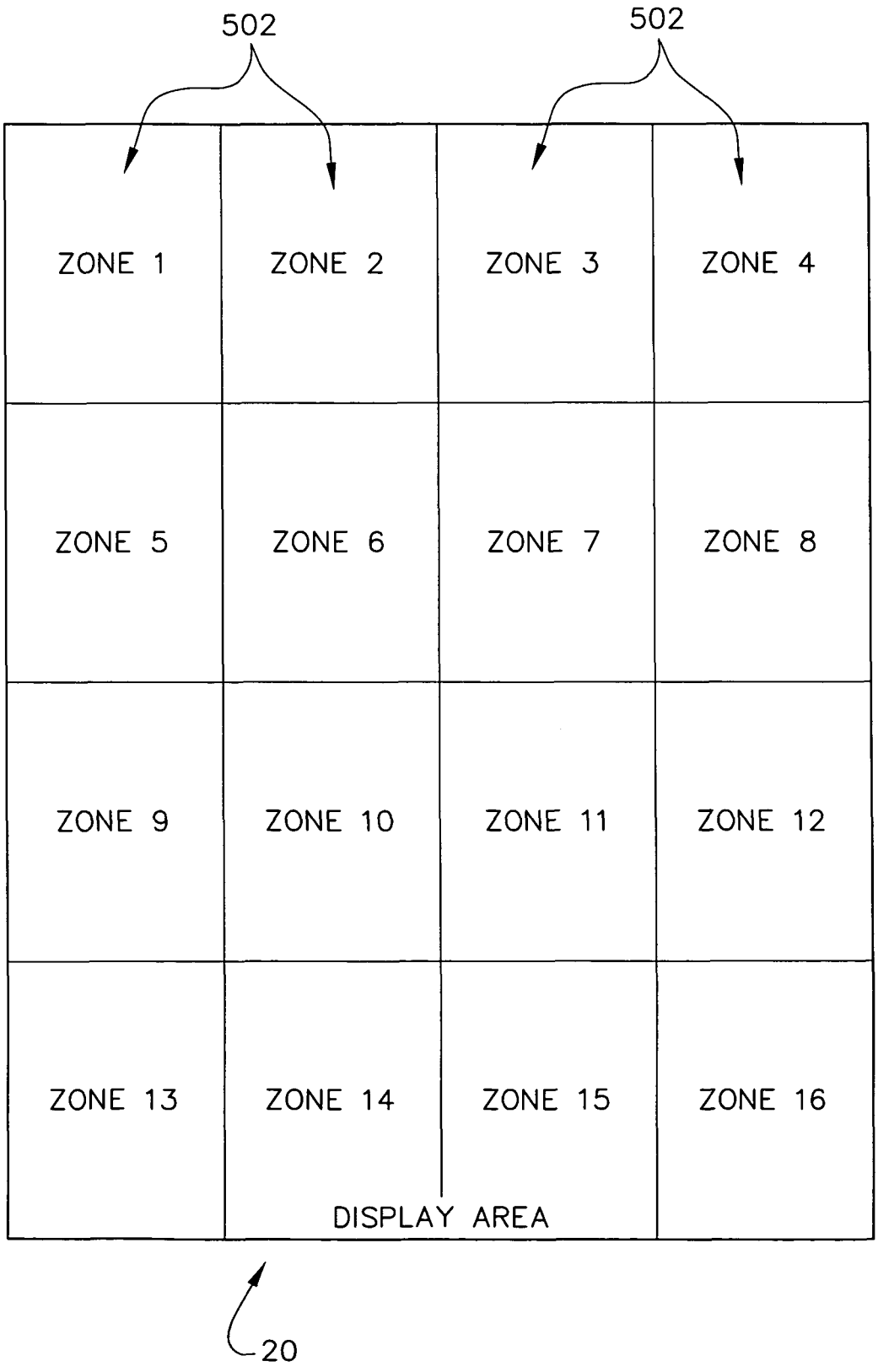

502
502
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
ZONE 6
ZONE 7
ZONE 8
ZONE 9
ZONE 10
ZONE 11
ZONE 12
ZONE 13
ZONE 14
ZONE 15
ZONE 16
DISPLAY AREA
20

FIG. 18

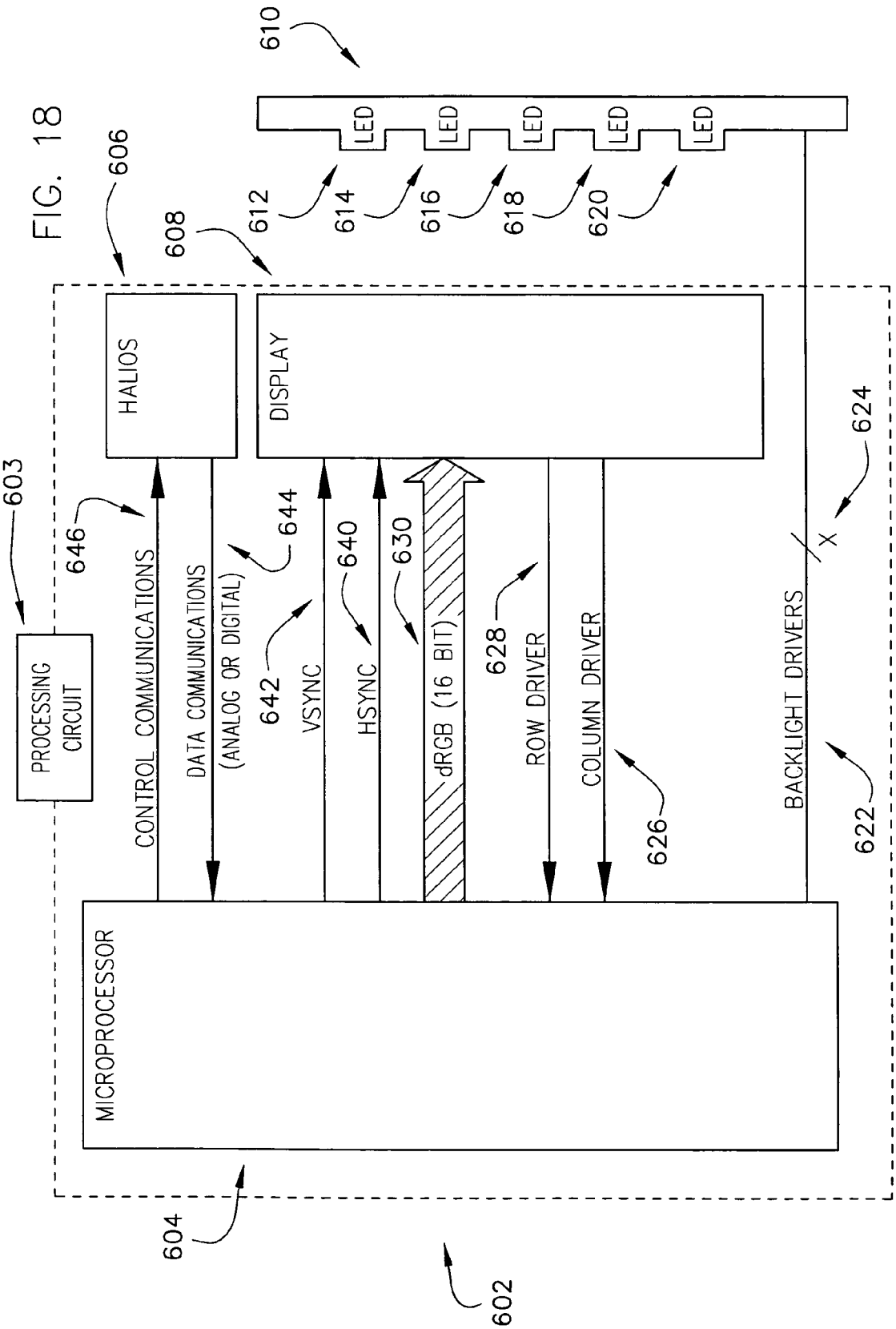

610
LED
LED
LED
LED
LED
612
614
616
618
620
606
608
HALIOS
DISPLAY
603
624
646
644
640
630
642
628
PROCESSING CIRCUIT
CONTROL COMMUNICATIONS
DATA COMMUNICATIONS (ANALOG OR DIGITAL)
VSYNC
HSYNC
dRGB (16 BIT)
ROW DRIVER
COLUMN DRIVER
BACKLIGHT DRIVERS
626
622
MICROPROCESSOR
604
602

FIG. 19

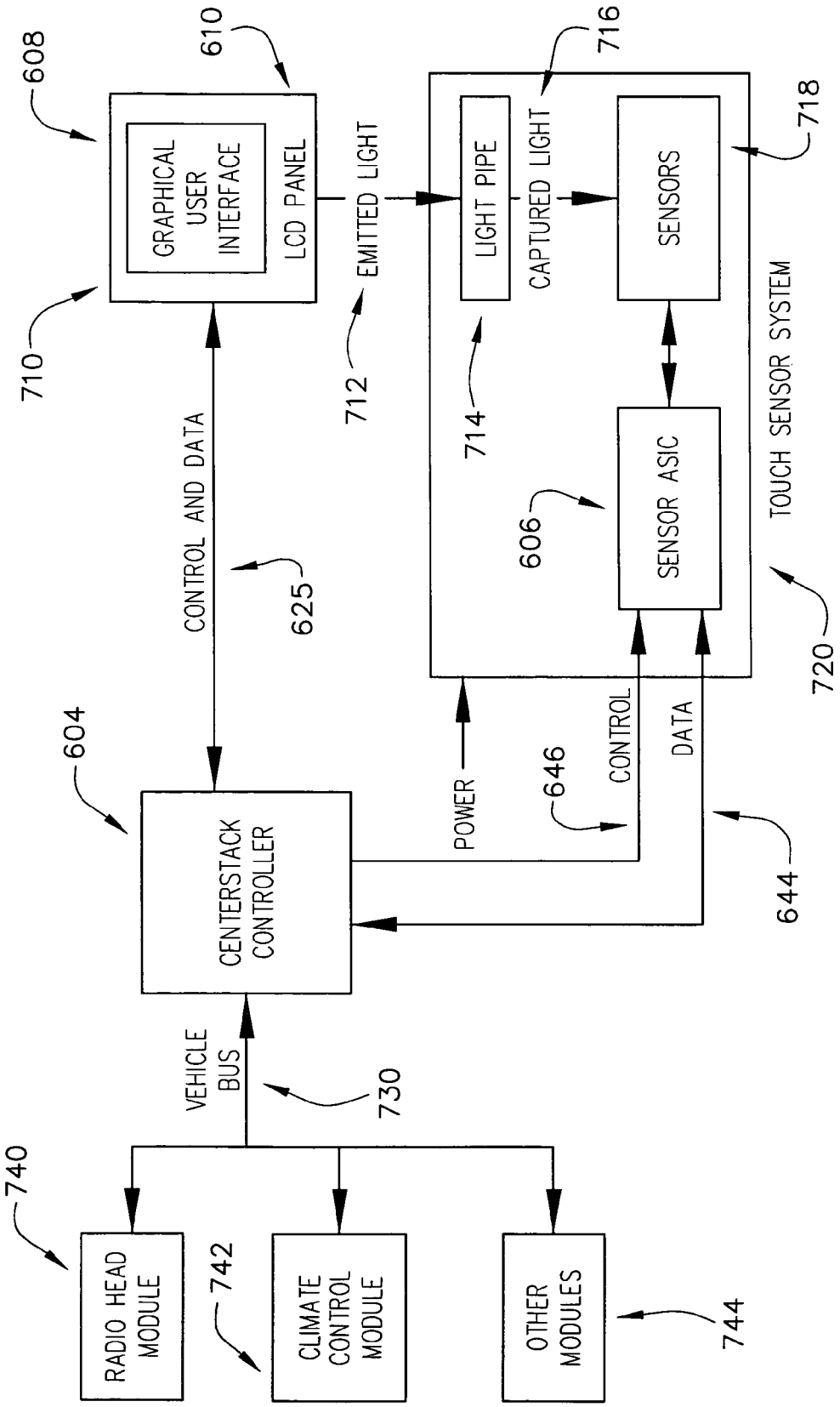

608
610
716
718
GRAPHICAL USER INTERFACE
LCD PANEL
EMITTED LIGHT
LIGHT PIPE
CAPTURED LIGHT
SENSORS
710
712
714
606
SENSOR ASIC
TOUCH SENSOR SYSTEM
CONTROL AND DATA
625
720
604
CENTERSTACK CONTROLLER
POWER
646
CONTROL
DATA
644
VEHICLE BUS
730
740
742
744
RADIO HEAD MODULE
CLIMATE CONTROL MODULE
OTHER MODULES

FIG. 20

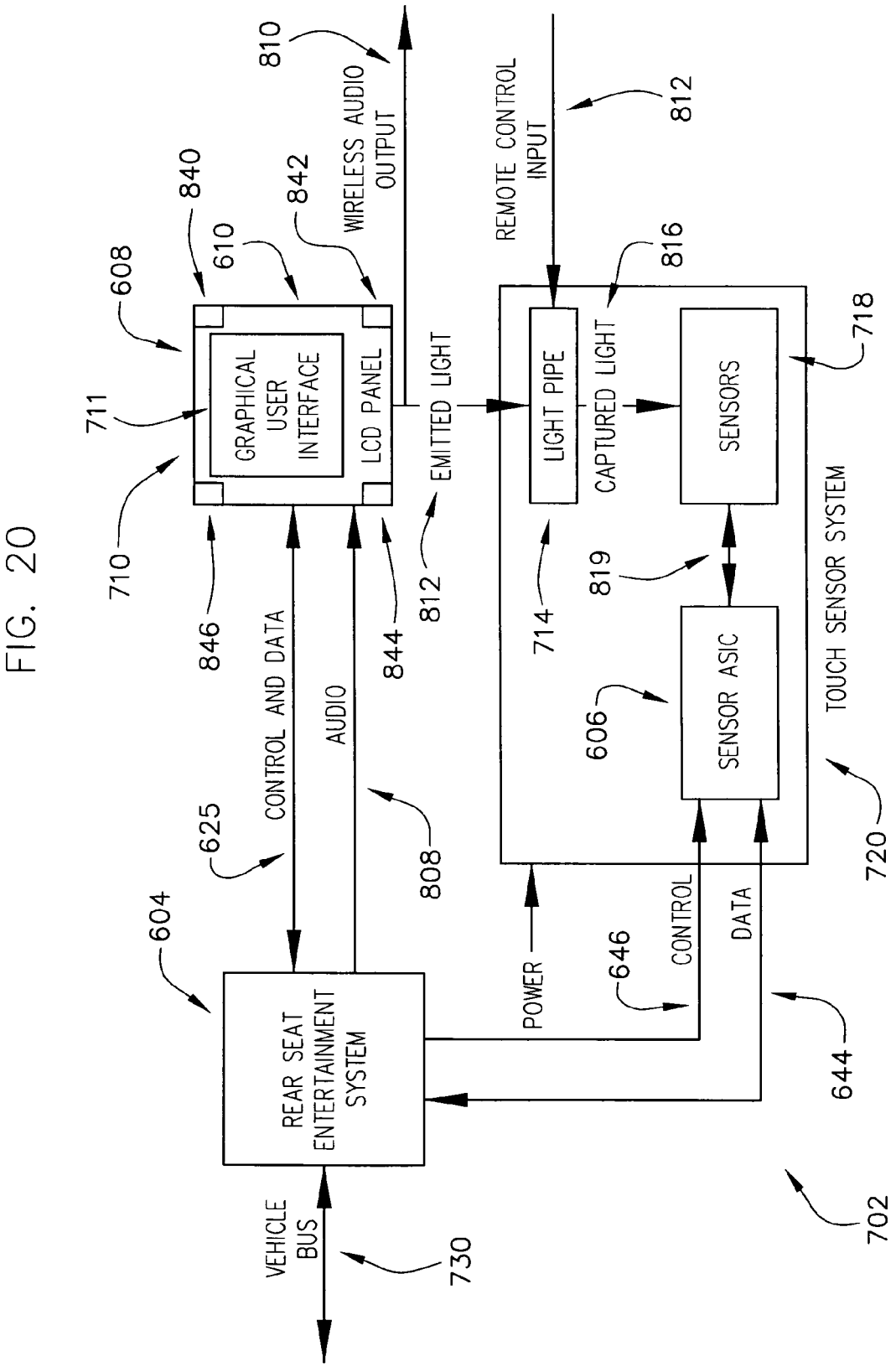

810
WIRELESS AUDIO OUTPUT
840
842
610
608
711
710
GRAPHICAL USER INTERFACE
LCD PANEL
EMITTED LIGHT
846
844
812
CONTROL AND DATA
AUDIO
625
808
604
REAR SEAT ENTERTAINMENT SYSTEM
VEHICLE BUS
730
REMOTE CONTROL INPUT
812
816
LIGHT PIPE
CAPTURED LIGHT
SENSORS
718
714
819
606
SENSOR ASIC
TOUCH SENSOR SYSTEM
720
POWER
646
CONTROL
DATA
644
702

FIG. 21

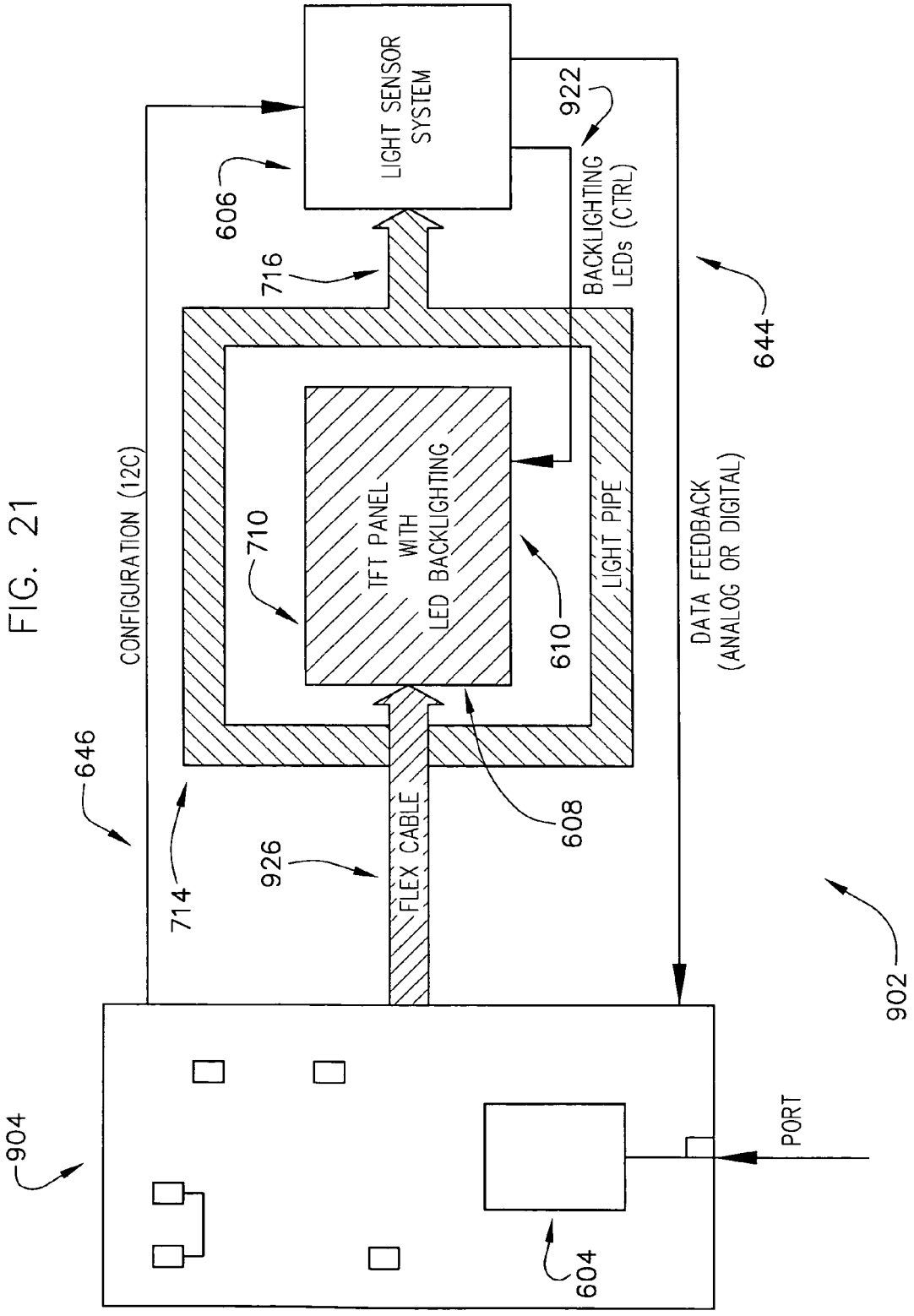

LIGHT SENSOR SYSTEM
606
922
BACKLIGHTING LEDs (CTRL)
716
644
CONFIGURATION (I2C)
710
TFT PANEL WITH LED BACKLIGHTING
610
LIGHT PIPE
DATA FEEDBACK (ANALOG OR DIGITAL)
646
608
714
926
FLEX CABLE
902
904
PORT
604

FIG. 23

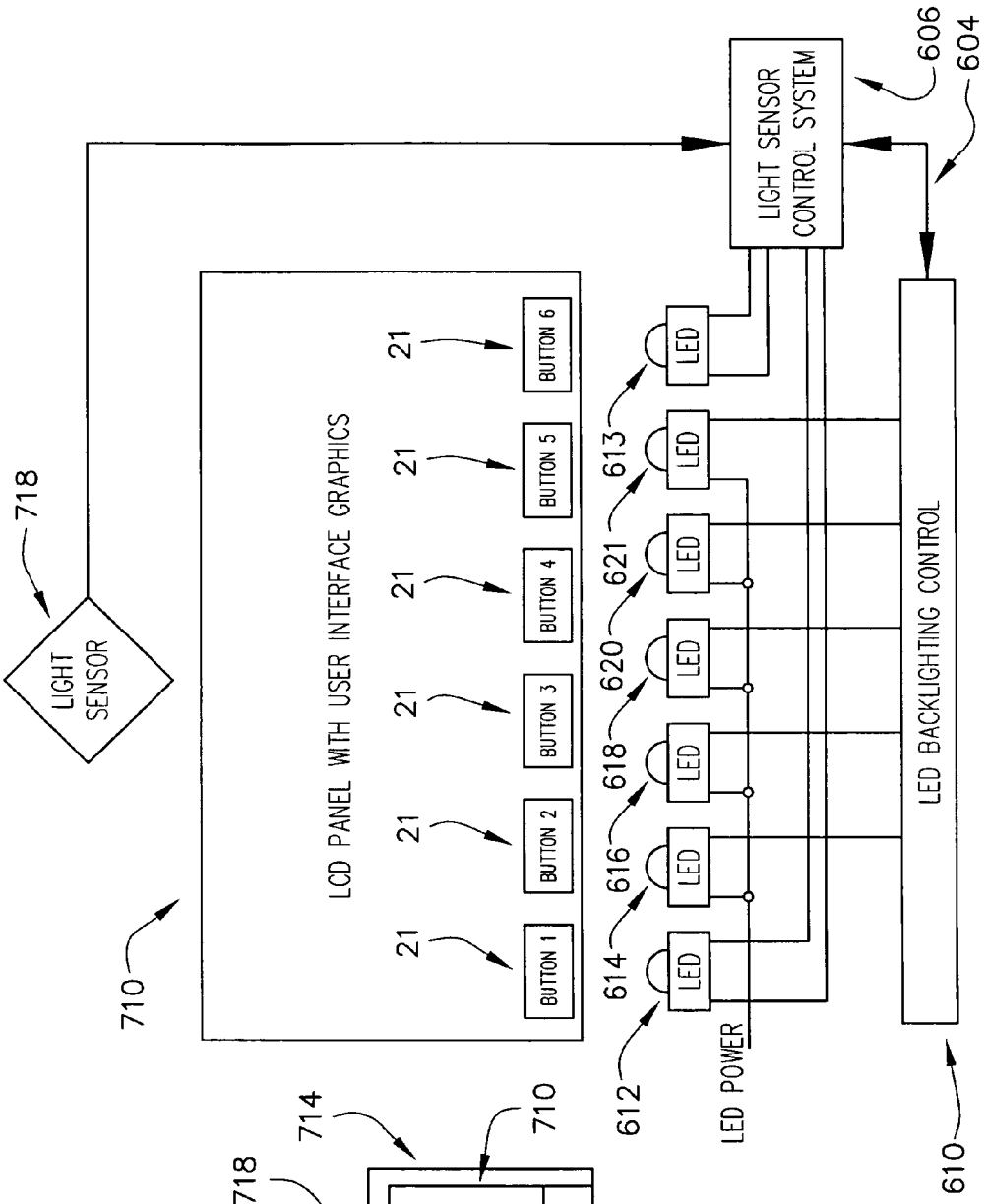

LIGHT SENSOR
718
LIGHT SENSOR CONTROL SYSTEM
606
604
LED BACKLIGHTING CONTROL
610
LED POWER
612
LED
614
616
618
620
621
613
710
LCD PANEL WITH USER INTERFACE GRAPHICS
BUTTON 1
BUTTON 2
BUTTON 3
BUTTON 4
BUTTON 5
BUTTON 6
21

FIG. 22

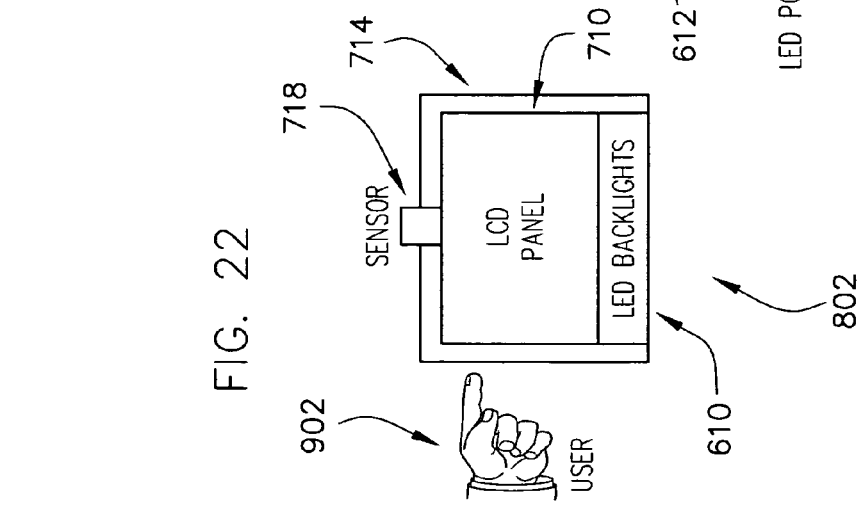
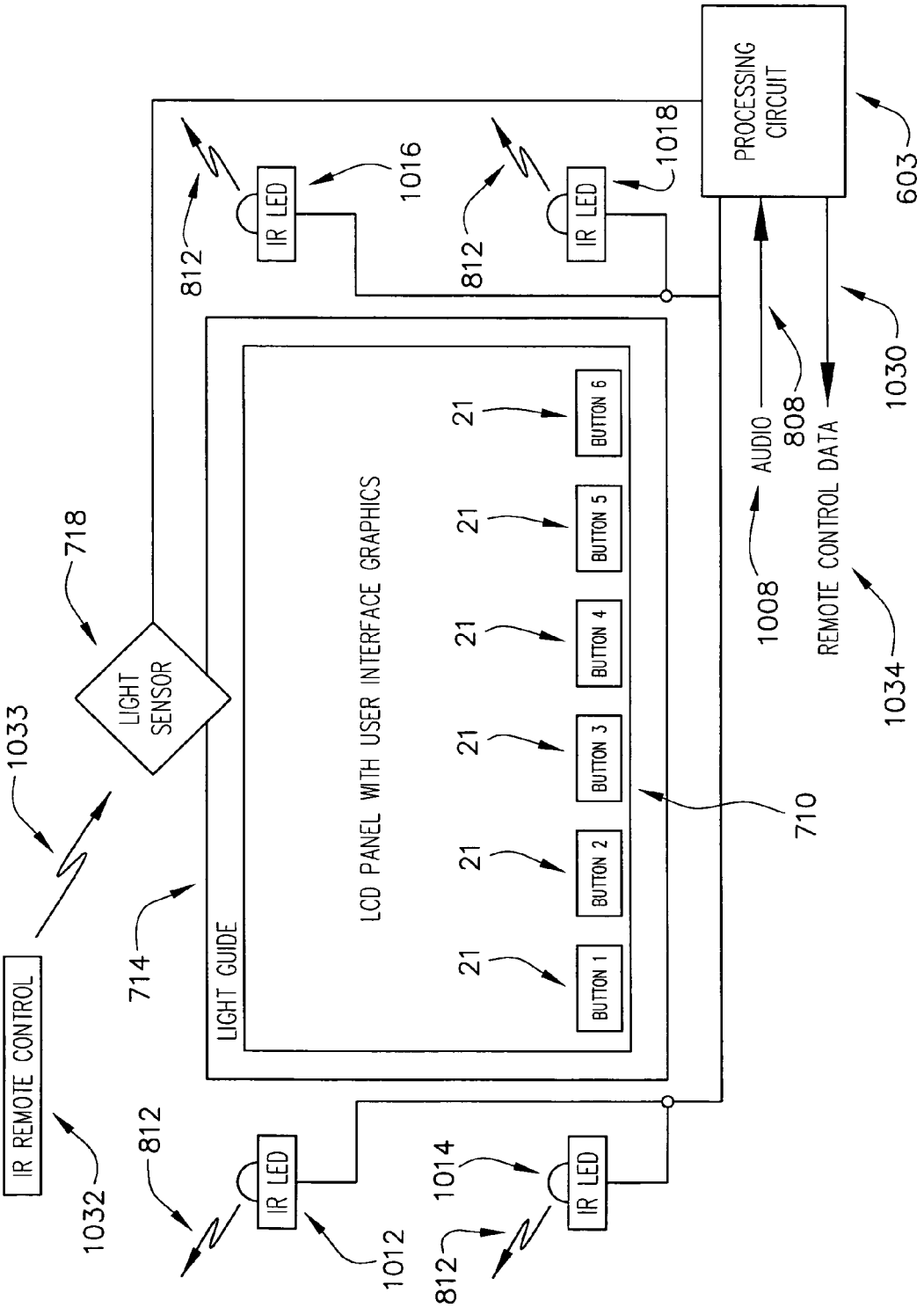

718
SENSOR
714
710
LCD PANEL
LED BACKLIGHTS
610
802
902
USER

FIG. 24


PROCESSING CIRCUIT
603
IR LED
1016
812
IR LED
1018
812
1030
AUDIO
808
REMOTE CONTROL DATA
1008
1034
718
LIGHT SENSOR
1033
IR REMOTE CONTROL
1032
714
LIGHT GUIDE
LCD PANEL WITH USER INTERFACE GRAPHICS
BUTTON 1
BUTTON 2
BUTTON 3
BUTTON 4
BUTTON 5
BUTTON 6
21
710
812
IR LED
1012
812
IR LED
1014

DISPLAY AND USER INTERFACE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a national stage application of PCT/US2007/025046, filed Dec. 5, 2007, which claims priority to U.S. Provisional Patent Application No. 60/873,780 filed Dec. 8, 2006, the entire disclosure of both which are hereby incorporated by reference.

BACKGROUND

The application is generally directed to the field of display devices and mostly (although not entirely) to methods for registering commands selected on the display.

Many types of touch screens exist. For example, some conventional touch screens use capacitance to determine that a user has touched a screen. A company named Digital Dash has developed a touch screen technology that uses machine vision to determine that a user has touched a screen. However, drawbacks exist for the various types of systems that register a user's selection of a command of the touch screen.

SUMMARY

A control system allows a user to initiate commands by selecting control regions displayed by a display. The system uses a sensor that is configured to detect light or other electromagnetic radiation reflected by a user as the user approaches the control region being displayed on a display surface of the display.

The reflected radiation may be light used to display an image on the display, may be radiation used to wirelessly transmit data (e.g. audio data to a wireless headphone system), and/or may be some other type of radiation (e.g. light used solely to determine whether control regions have been actuated).

The radiation (e.g. light) to be analyzed may be given one or more unique characteristics such that the radiation (e.g. light) to be analyzed may be easier to identify. The unique characteristic could be any characteristic as discussed below. In some embodiments, the unique characteristic is a frequency at which the radiation is modulated. In some embodiments, the uniquely characterized radiation is associated with a particular control region. In other embodiments, the uniquely characterized radiation is generally provided and/or may be associated with more than one region.

The display may be any type of display. In particular embodiments, the display may be a flat panel display.

Other features may be gleaned from the disclosure below, including the examples and illustrative embodiments. Some embodiments will be combinations of any of the embodiments discussed above with each other (and all such possible combinations are contemplated) and/or with any of the additional features discussed below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of a touch sensor for a display according to one embodiment;

FIG. **2** is a display system using a panel display according to one embodiment;

FIG. **3** is an illustration of a display screen having a control button according to one embodiment;

FIG. **4** is an illustration of a display system along the cross section illustrated in FIG. **4** according to one embodiment;

FIG. **5** is a diagram of a frequency of detected light as a user approaches a control region;

FIG. **6** is a diagram of a frequency of detected light as a user approaches a non-control region of the display;

FIG. **7** is a diagram showing combined outputs of light reflected from a control and a non-control area of the display;

FIG. **8** is directed to a control scheme for the correction of ambient light;

FIG. **9** is directed to a system for correcting for the presence of ambient light;

FIGS. **10-12** are directed to changeable display systems according to various embodiments;

FIGS. **13** and **14** an illustration of creating changeable artificial shadows according to one embodiment;

FIG. **15** is a display system according to one embodiment.

FIG. **16** is a display screen using both time and frequency to differentiate various control regions;

FIG. **17** is an illustration of a display screen having a control button according to one embodiment;

FIG. **18** is a diagram of a display system according to one embodiment;

FIG. **19** is a diagram of a display system according to the embodiment of FIG. **18**;

FIG. **20** is a diagram of a display system according to one embodiment;

FIG. **21** is a diagram of a display system according to one embodiment;

FIG. **22** is a diagram of a display system according to one embodiment;

FIG. **23** is a diagram of a display system according to the embodiment of FIG. **22**; and

FIG. **24** is a diagram of a display system according to one embodiment;

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Referring to FIG. **1**, a display system **10** includes a display **20** configured to provide a user with information. The display includes control regions **21** which represent areas of the display **20** that a user can actuate to control various functions of display **20** and/or non-display systems **28**. Display **20** may display the information relating to the function controlled by control region **21** or control region **21** be "invisible" to a user such that the control regions **21** exist but a user would not be able to differentiate the area of the display **20** corresponding to the control regions **21**. Further, some control regions **21** may be visible while others are not visible. Further still, a displayed image that appears to be a single control may include multiple control regions **21**.

Actuation of a control (signified by a control region **21**) by a user can be determined using a light-based control system. As a user approaches display **20** (e.g. points at a portion of display **20** with their finger), the user may tend to reflect light (e.g. reflect light) from display **20**. Sensors **12,14** may be placed in regions around the display **20** such that they are capable of sensing this reflected light. Light guides **16,18** may be used to increase the areas in which light can be detected. Light guides **16,18** may be configured to guide light to sensors **12,14**, which sensors **12,14** may be located in front of the display surface on which the image of a control region **21** is displayed and/or may be located behind the display surface on which the image of a control region **21** is displayed.

Display **20** may be configured to display different regions **19,21** with different characteristics which can be used to distinguish the regions **19,21**. For example, each region **19,21** may be displayed at a unique time. Each pixel of display **20**

could be actuated in sequence such that only one (or a limited number) of pixels are active at a given time (see, e.g., the embodiment of FIG. **2**). As a second example, light displayed at each region may be displayed at a different amplitude. As a third example, each region **19**,**21** may be displayed using light that is modulated at a different frequency (see, e.g., the embodiment of FIGS. **3**-**7**). As a fourth example, each control region **21** may be displayed using a unique color that may or may not be noticeable by a user. As a fifth example, the display back light may be modulated such that the position of the touch can be determined and correlated to the control region.

Sensors **12**,**14** can be configured to be capable of preserving at least a portion of these differences when light is captured by the sensors. For example, sensors **12**,**14** may be reactive enough to identify that light is being modulated at a high frequency, to give an accurate assessment of a time at which light was reflected by a finger, etc.

Processing circuit **22** is configured to receive the data output from the sensor and identify the differing characteristic of the various regions **19**,**21** of display **20** (e.g. may determine the coordinates of the display from which the light was reflected based on the data, may correlate a particular characteristic with a particular control region, etc.). Once processing circuit **22** identifies the value of the characteristic, processing circuit **22** can be configured to determine whether the characteristic corresponds to a control region **21** or a non-control region **19** and/or to determine the specific control region **21** to which the characteristic corresponds (if multiple control regions **21** are present).

Based on the determination of the control option, processing circuit **22** can be configured to send data (including control signals) to display driver **24** and/or various other systems **28**, which may be used to control those systems **24**,**28**.

Embodiment Using a Flat Panel Display and Time Differentiation

Referring to FIG. **2**, one embodiment of system **10** includes a light guiding element **18** is placed around the perimeter of the front portion of a flat-panel display **20**. Light guiding element **18** helps guide light into light sensor **12**, which, as discussed above, may be in front of or behind the display surface of display **20**.

Light sensor **12** and a controller (not illustrated) for display **20** provide data to a processing circuit **22** (FIG. **1**). The controller for the display may be configured to control display **20** to illuminate each pixel individually and/or sequentially. The controller provides processing circuit **22** information indicating when display **20** is displaying each control region **21** (e.g. information such as the horizontal synch pulse, vertical synch pulse, and/or dot (pixel) clock of an LCD or other display). Based on this information, processing circuit **22** can be configured to determine whether an object is approaching a control region **21**.

Light sensor **12** and a controller (not illustrated) for display **20** may be configured to provide data to a processing circuit **22** (FIG. **1**). The controller for the display may be configured to control display **20** to modulate one or more of the back lights for the display. In other embodiments, processing circuit **22** may control the controller's modulation of one or more of the back lights of the display. In these embodiments, processing circuit **22** may or may not receive data from the controller. Processing circuit **22** may be configured to receive the data output from the sensor and identify approximate location (e.g. coordinates such as x & y coordinates, general region, etc.) on the display that correspond to the reflected light. Once processing circuit **22** identifies the location (e.g. coordinates), it may be configured to determine whether a user input has been received (e.g. if the location corresponds to a control region **21**, a non-control region **19**, or no region of the display), and/or send data (e.g. coordinates) based on the received (and possibly also processed) data to another circuit (e.g. over a vehicle communication system such as a vehicle bus).

For example, processing circuit **22** may be configured to record a time at which sensor **12** picks up reflected light and compare that time to the time during which pixels corresponding to the control region **21** are being illuminated. If they match, then a user is likely reflecting light generated by the control region. As another example, processing circuit **22** may control sensor **12** to only operate during those periods during which control regions are being illuminated on display **20**. If sensor **12** detects light during those periods when it is operational, then processing circuit **22** may determine that a user is reflecting light generated by the control regions. As still another example, instead of (or in addition to) controlling sensor **12** to only operate during certain periods, processing circuit **22** may be configured to ignore/discard data (for the purpose of determining if a control region is being actuated) sent from sensor **12** during periods when no control regions **21** are active.

A control region **21** may be displayed using a number of pixels (e.g. at least about 20 or 40 pixels wide by at east 2 or 4 lines in some embodiments). Processing circuit **22** may be configured to look for reflections of light during periods when the more central pixels (i.e. the pixels not at one or multiple edges) are illuminated.

A panel display **20** may be formed from any number of different materials. For example, panel display **20** may be an LCD display, an OLED display, a solid-state display, etc.

Panel display **20** can be flat, as shown in FIG. **2**, or may be formed in a non-flat shape such as a curved shape, including curved shapes that are bent around more than one axis.

A panel display may use a differentiating characteristic other than time differentiation and time differentiation may be used with displays other than panel displays.

Embodiment Using a Projector-Based Display and Frequency Differentiation

Referring to FIGS. **3** and **4**, light is provided (e.g. projected) from an image source **104** (e.g. projector) of display **20** onto a display surface **102** (e.g. screen) of display **20**. When image source **104** provides light to non-control regions **106**,**108**, image source **104** may be configured to modulate its light source (not shown) at a first frequency (e.g. 180 Hz), and modulate light at a second frequency (e.g. 5000 Hz) when providing light to control region **21**. In some embodiments, the second frequency will be at least 10 times that of the first frequency.

So that an image can be projected onto a curved surface **102**, a light-scattering pane of suitable shape and light-scattering behavior may be used. The projector **104** behind this matte pane **102** can make use of any one of numerous different technologies.

The projector **104** may operate with a brightness frequency that is faster than the resolving time of the human eye. One type of projector **104** that may be used is a DMD ("Digital Micro-mirror Device") based projector display. This type of projection device may use a source of white light that passes through a filter wheel to send red, green, and blue components in succession to the DMD. In the DMD, very tiny mirrors are typically controlled in such a way that they reflect the light required for the image to be projected on a path leading to the screen **102**. This light is generally projected in coordination with the rotation of the color disk to produce the correct color. Pixel intensity (brightness) may be controlled in this type of

device by varying the amount of time during which a particular pixel is projected. Each mirror generally has its own projection point. If the light is reflected onto the screen for only short periods of time, the brightness at this point will be weak.

The mirrors tend to react so quickly that the eye sees only the final position of the mirror, not the path of reflection itself. At high reflection frequencies, the human eye with its slow reaction time generally does not perceive the rapid alternation of a pixel between light and dark as a series of individual events but rather as a brightness value, the intensity of which depends on the selected pulse-pause ratio.

FIG. **4** shows a cross section through a display **20** (see FIG. **3**) that includes a projector **104** and the associated plane of projection **102** having a control region **21**. The path and/or distance from the projector **104** to the plane of projection **102** can be altered by the use of mirrors, lenses, etc.

To differentiate control regions **21** and non-control regions **106**,**108**, the control region **21** can be clocked at a frequency outside the spectrum of the pixels normally used for image data (the non-control regions **106**,**108**).

As one example that may be used, for a display **20** targeting a frame frequency of 60 Hz (60 frame changes per second) then, on the basis of the division into red, green, and blue, the pixels are driven at a frequency of 3×60 or 180 Hz. A frame frequency outside of 180 Hz (e.g. 5,000 Hz) can be selected for the control region **21**.

In the example discussed above, in the area of the control region **21** the emitted light frequency is increased from about 180 Hz to 5,000 Hz. A hand approaching the control region **19** to actuate it may tend to reflect some of the emitted light. This reflected light may be received by one or more photodiodes **12**,**14** (FIG. **1**) placed at the edges of the control region **21**, behind the control region **21**, etc. As shown in FIG. **5**, after appropriate amplification, a signal with a specific spectrum can be obtained at the output of an amplifier.

In the areas **106**,**108** of display **20** outside of the control region **21**, the spectral component of the reflected light will correspond to that of the actual image data as shown in FIG. **6**.

An optical sensor **12**,**14** (FIG. **1**) may, of course, pick up the information from the control region **19** and the image data outside the control region **19** simultaneously. FIG. **7** shows the spectrum consisting of the non-control region **106**,**108** image data and the control region **21** image data as it would be detected by an optical sensor **12**,**14** that covers the entire illuminated area. Because the two spectral regions are distinguishable, it can be easier to assign the correct one to the light reflected from a finger.

If several control regions **21** (FIG. **1**) are displayed simultaneously, they may be actuated in succession, making it possible to assign the reflection data present in the received signal to its associated control region **21**. It is also possible to distinguish between reflections from different control regions **21** by the use of different frequencies for each control region **21**. Any other different characteristics may also be assigned to the multiple control regions **21** to differentiate the control regions **21** (as discussed below).

Projector-based displays may use a technique for differentiating control regions other than frequency differentiation. Also, frequency can be used to differentiate control regions in displays other than projector displays.

Embodiment Using Intensity Differentiation

Referring back to FIG. **1**, in addition to the methods described above that use characteristics of light as it is emitted by display **20** to distinguish control regions **21** from non-control regions **19**, system **10** could also use characteristics of the light as it is received by sensors **12**,**14**. For example, the intensity of light at one or more of sensors **12**,**14** may provide information suggestive of the location at which light is being reflected. If sensors **12**,**14** are placed at opposite corners of display **20**, strong intensity at one sensor **12** and weak intensity at another sensor **14** may suggest that a user is reflecting light from a spot that is closer to sensor **12** than sensor **14**. Equal intensity at light sensors **12**,**14** may suggest that user is reflecting light at a point that is equidistant from sensors **12**,**14**.

In addition to the relative intensities of light received at sensors **12**,**14**, the absolute intensity of light received by sensors **12**,**14** may provide information regarding the distance a point being "touched" by a user is located from the sensors. The intensity of light received by each of sensors **12**,**14** can be compared to the intensity of light being given off by display **20** (i.e. the brightness of display **20**, particularly at a given point or points).

Light guides **16**,**18** can be used to affect the light intensity information received by sensors **12**,**14**. Light guides may be shaped to provide additional information (e.g. could be designed to provide increased intensity at one or both sensors **12**,**14**), could be placed in areas to provide more information (e.g. light guides that provide light to different sensors could have regions of overlap), could be made of materials of differing light conductivity (e.g. to provide more intense guiding of light on one side of a display **20** than the other side), etc.

A light sensor **12**,**14** may be configured to determine a relative intensity of multiple (e.g. two or three) frequency ranges (colors) of light. In this case, the relative intensities of the colors received by sensors **12**,**14** may be compared to the various relative intensities of colors in the various regions of the image displayed by display **20** to provide information regarding which region is being "pressed" by a user.

Embodiment Using a Panel Display and Frequency Differentiation

Referring to FIG. **17**, a panel display includes areas illuminated by separate lighting elements. An area **502** can be one pixel in size or can be a zone. The lighting element for each area **502** can be illuminated with a different characteristic. For example, each lighting element can be modulated at a different frequency. As another example, each area can use a different frequency (e.g. color or shade of color) or light. Different frequencies of light can be purposely chosen, or variation may be an inherent property of the light source. For example, different LEDs from different "bins" may have different frequencies for a given color. In either case, the characteristic may be determined (e.g. during manufacture) and stored in the memory of processing circuit **22**. As another example, each region may be illuminated at a different time. For example, Zone 1 and Zone 9 may both be operated at the same frequency, but might be operated at different times which allows processing circuit **22** to differentiate between Zone 1 and Zone 9.

Based on the differing characteristics for each zone **502**, processing circuit **22** can determine which zone **502** is being actuated by a user. Differences within a zone **502** (color, relative color intensities, time, etc.) can be used to differentiate various portions of the zone **502**. In other embodiments, control regions **21** may occupy an entire zone **502**. Such zones **502** may be specially shaped (i.e. shaped different from other zones) to conform to a desired shape for control regions **21**.

In one example, display **20** may be an LCD panel display that is backlit by one light source with separately controllable areas, or which includes more than one light source. The light source(s) may be an LED (e.g. an OLED), may be an electroluminescent (EL) light source (e.g. an EL panel), a cold cathode fluorescent lamp (CCFL), a hot cathode fluorescent

lamp (HCFL), an incandescent light source, a solid state light source, and/or may be some other light source. If a single LED is used for a given zone **502**, the LED would preferably have a spectrum that includes light in at least three (e.g. red, blue, and green) color regions (e.g. a blue LED with red-emitting and green-emitting phosphors).

Exemplary Display Systems

Referring to FIG. **18**, an exemplary display system **602** incorporating a user input sensor system includes a processing circuit **603**. Processing circuit **603** includes a processor **604**, a sensor circuit **606** (e.g. an integrated circuit (IC), such as an ASIC, configured to process data from a sensor), and a display control circuit **608**.

Processor **604** coordinates operation of the display system **602**. Processing circuit **604** sends data **630-642** to display control circuit **608** to control the information being displayed on the display controlled by display control circuit **608**. For example, processing circuit **604** may provide image data **630**, a horizontal timing signal **640**, and/or a vertical timing signal **642** to display control circuit **608** which may be used by display control circuit **608** to control a display to display information. The displayed information may include control regions. Processor **604** retains data relating to which control region(s) were displayed at which locations (and/or at which times) on the display. Display control circuit **608** may be configured to process the data **640-642** received from processing circuit **608** and provide data **626-628** back to processing circuit **604**. For example, display control circuit **608** may be configured to control a display to display information based on the data **630-642** received by display control circuit **608** but not at the exact time dictated by the timing data **640**, **642** received by display control circuit **608**. Display control circuit **608** may be configured to provide exact timing data **626**,**628** (e.g. data **628** relating to the operation of a row driver circuit and data **626** relating to the operation of a column driver circuit used to control the display) back to processing circuit **604**, which data may be stored (at least temporarily) by processing circuit **604** (e.g. processing circuit **604** may be configured to store data—based on data **626**,**628**—relating to when and/or where control regions were displayed by the display).

Processor **604** may also be configured to control an illumination system **610** used to display information on the display. For example, the display may be a panel display that is backlit by one or more light sources **612-620** (e.g. solid state light sources such as LEDs, OLEDs, EL panels, etc.). Processor **604** may be configured to send a control signal **622** that is configured to control illumination of one or more light sources **612-620**. Control signal **622** may include one or more signals **624** where each signal **624** may be configured to control operation of one or more light sources **612-620** of illumination system **610**. Processor **604** may be configured to modulate one or more light sources **612-620**. For example, processor **604** may be configured to modulate two or more (e.g. at least three, at least four, at least five, or more) light sources **612-620** at different frequencies than other light sources **612-620** such that sensor **606** would be able to identify light received from the specially modulated light sources **612-620**. As another example, processor **604** may be configured to control timing of when light sources **612-620** are providing illumination such that two or more (e.g. at least three, at least four, at least five, or more light sources) are illuminated during distinct periods identifiable by a sensor circuit **606**. The light sources **612-620** illuminated may be constantly changing, or the light sources **612-620** may be constantly illuminated except for short durations (e.g. less than 20%, less than 15%, less than 10%, less than 5%, and/or less than 1% of the total time during which light is provided by light sources **612-620**) during which the light sources are specially modulated to provide the distinct periods. As another example, light sources **612-620** may be illuminated cyclically (e.g. may be pulse width modulated) and two or more (e.g. at least three, at least four, at least five, or more) light sources **612-620** may be illuminated out of phase with each other and with the other light sources such that a sensor circuit **606** may be able to identify light from the light sources **612-620** that are out of phase.

The unique characteristics of light imparted by processor **604** (e.g. timing **640**, modulation **622**, color **630**, etc.) may be used to uniquely identify light reflected by a user as the user approaches a control region. In some embodiments, the unique characteristics could also be used to identify that a user is approaching non-control regions.

In particular, processor **604** may provide data **646** to a sensor circuit **606**. The data **646** may include configuration data (e.g. data used to control settings of the sensor such as sampling frequency, ASIC set-up, etc.), data relating to the operation of the display-based control system (e.g. data relating to the unique characteristics of the image displayed such as characteristics of light from the light sources like color, modulation frequency, modulating timing, and/or other characteristics of light from the light sources; characteristics such as timing of the display of the control regions; etc.).

Sensor circuit **606** may be configured to receive sensor data from the sensor representative of a light input received by the sensor, and may process the sensor data based on the data **646** received from the processor **604**. Sensor circuit **606** provides output data **644** based on the processed data. In some embodiments, sensor circuit **606** may be configured to provide data representative of a location on the displayed image that may have been actuated by a user (e.g. may provide a coordinate—such as an x-y coordinate—of a location actuated by a user, may provide data relating to which control region was actuated by the user, etc.).

Processor **604** is configured to receive the data **644** from sensor circuit **606**. Processor **604** may further process the data. In some embodiments, processor **604** may process the data to control a system based on the data **644**. For example, processor **604** may correlate data **644** from sensor circuit indicative of which control region was actuated and implement the command associated with the control region. Implementing the command may include implementing the command in the processor **604** (e.g. changing the information **630** displayed on a display, etc.), sending a control signal to a separate system to control a function of that system (e.g. control a rear seat entertainment system, control an HVAC system, control a GPS system, etc.), or could include implementing the control by some other means. The processing of the data **644** to implement the command could include correlating coordinate information **644** received from sensor circuit **606** with data (e.g. data **626-630**) relating to the information displayed by the display to identify control regions corresponding to the coordinates identified by sensor circuit **606**, correlating a control region identified (e.g. by sensor circuit **606**, by processor **604**, etc.) with a specific command (e.g. a set of commands) to be implemented, etc.

Referring to FIG. **19**, a display system **602** may be constructed similarly to the system of FIG. **18**. Display system **602** includes a display **710** (e.g. an LCD panel display) and a touch sensor system **720**. Display **710** may be configured to display control regions on a graphical user interface (GUI) **711**, and touch sensor **720** may be configured to determine whether a user has actuated one of the control regions. Touch sensor **720** may be configured to determine whether a control

region has been actuated without requiring that a user actually touch display **710** (or, in some embodiments, touch any portion of display system **602**).

In operation, backlights **610** for display **710** may be given a characteristic as discussed with respect to FIG. **18**. Light **712** from display **710** is reflected and collected by light pipe **714**, which may be a light guide used to display information on display **710** (e.g. a light guide of an LCD panel), may be a separate light guide, and/or may use both a light guide of display **710** and a separate light guide.

Light **716** captured by light pipe **714** is transferred to sensor **718** which produces a signal **719** based on the light **716** received. A sensor circuit **606** may be configured to processes the signal **719** received from sensor **718** to provide output data **644** (as discussed above).

The output **644** of sensor **606** may be provide to a processor **604** which may be a vehicle controller such as a centerstack controller that controls various input devices and/or displays associated with the vehicle's centerstack. Processor **604** may be coupled to other vehicle systems **739** (e.g. a radio module **740**, a climate control module **742**, and/or some other module **744**) directly or indirectly (e.g. over a vehicle bus **730** which may be wired or may be wireless).

Referring to FIG. **20**, a display system **702** may be configured similarly to the display systems of FIGS. **18** and **19**. Display system **702** is configured to provide wireless transfer of an audio output **810** (e.g. via an infrared signal to an IR headphone), wireless receipt of commands from a remote control input **812** (e.g. an IR remote), and a touch screen user input system **720** using common components.

Display system **702** operates similar to system **602**. Instead of (or in addition to) controlling light sources **610** to have unique characteristics, system **702** may also include additional light sources **840-846** (e.g. infrared light sources or sources of non-visible light generated from any of the types of light sources discussed above or below) that are configured to provide a light output **812**. Light sources **840-846** may be located behind a graphical output surface of display **710** (e.g. behind the liquid crystal gates of an LCD display, behind the display screen of a projector-based display, etc.), to the side of the display **710**, and/or in front of the display **710**. Light output **812** may be reflected by a user approaching display **710**, and routed to sensor **718** via light pipe **716** as discussed above. Light output **812** may also be used to provide an audio output **810**. For example, light output **812** may include a frequency, amplitude, or otherwise modulated signal portion that carries audio content.

In addition to receiving light **812**,**816** reflected from a user (e.g. a user's finger, a pointer, and/or some other object) approaching display **710** (representing possible actuation of a control region of graphical user interface **711**), sensor **718** and/or light pipe **714** may be configured to receive an input signal **812** from a remote control (e.g. a remote control used by a user to control display system **702** and/or other systems). Sensor circuit **606** may be configured to process a signal **819** portion based on a signal **812** received from a remote control, or may be configured to pass along the remote control signal portion unprocessed.

In this manner, a touch input system **720** from user input from a user approaching a control region of display **710**, a wireless remote control system, and a wireless audio system can be implemented in a single device by using common components.

Referring to FIG. **21**, a display system **902** may be constructed similar to display system **602** discussed above. Display system **902** differs from display system **602** in that one or more of light sources **610** are controlled by sensor circuit **606** via a control line **922**.

Similar to display system **602**, display system **902** may be connected to display **710** (e.g. circuit **608**) via a flexible cable, which cable may transport one or more signals **626-642** (FIG. **18**) between processor **604** and circuit **608**. Also similar to display system **602**, display system **902** may include processor **604** on a circuit carrying element **904** separate from display **710** (including circuit **608**) and sensor circuit **606**. Circuit carrying element **904** may include various other control circuits for controlling display **710**, interacting with sensor **606**, processing data, controlling other systems, communication over a vehicle bus, and/or other functions. In other embodiments, two or more of the sub-circuits of processing circuit **603** (FIG. **18**) (e.g. processor **604**, display circuit **608**, sensor circuit **606**, etc.) may all be carried by a common circuit carrying element (e.g. circuit carrying element **904**).

Referring to FIGS. **22** and **23**, a display system **802** is constructed in a manner similar to display system **602**. System **802** differs from system **602** in that some of light sources **614-621** are controlled by processor **604**, while others of light sources **612-613** (e.g. at least two light sources, at least three light sources, at least four light sources, and/or more light sources), such as two or three light sources, are controlled by sensor circuit **606**. In some of these embodiments, the light sources **612-613** that provide the light used by system **602** to determine whether a control region **21** has been actuated (e.g. light having a detectable characteristic) are controlled by sensor circuit **606**, while the other light sources are controlled by processor **604**.

Referring to FIG. **24**, a display system **1002** is constructed similarly to display system **702** (FIG. **20**). Display system **1002** uses a light sensor **718** that may receive light reflected from a user that is indicative of actuation of control regions **21** displayed on a display **710**, and light (e.g. infrared light) **1033** encoded with commands provided by a remote control **1032**. A signal based on the light **1033** containing the commands may be received by processing circuit **603** from sensor **718**, and, in response, processing circuit **603** may output commands (or other data based on the commands) as data **1034** to other systems.

Display system **1002** also includes light sources **1012-1018** that provide output light **812** in a manner similar to any of those discussed above or below (e.g. in one or more of the manners discussed with respect to light sources **812-820** of FIG. **18**). Light output **812** may also be used to provide data such as an audio output (similar to output **810** of FIG. **20**). The audio output may be based on an audio signal **1008** received by processing circuit **603**.

Light sources **1012-1018** may be directly or indirectly controlled by one or more portions of processing circuit **603**, such as sensor circuit **606**, processor **604**, display circuit **608**, etc.

Additional Features of System **10**

Still referring to FIG. **1**, sensors **12**,**14** may be located in front of the display surface (e.g. screen) of display **20** and/or may be located to the sides of display **20**. In some systems (such as those using a projector or a light guide), sensors **12**,**14** may be located behind the display surface **102** (FIG. **4**) of display **20**. Generally, being in front of or to the side of display **20** is judged with respect to the display surface **102** of the display **20**.

Additionally, while two sensors are shown, any number of sensors (e.g. **1** sensor, a plurality of sensors, a large number of sensors, etc.) may be used. The sensors may be point sensors (such as diodes) which have a resolution of 1×1, or may

include an array sensor (e.g. a sensor comprised of an array of diodes, a CCD sensor, a CMOS sensor, etc.) which has a resolution of N×M pixels (e.g. an array where N=1, where M=1, where N>1, and/or where M>1). In some embodiments, one or more sensors have up to 2500 pixels, up to 2000 pixels, up to 1000 pixels, up to 500 pixels, up to 400 pixels, up to 300 pixels, up to 200 pixels, up to 100 pixels, up to 75 pixels, up to 50 pixels, up to 25 pixels, up to 15 pixels, and/or up to 5 pixels. Each of the sensors **12**,**14** that are used may be a same type of sensor or may be different types of sensors. In most embodiments, light sensors **12**,**14** are not cameras.

Light guides **16**,**18** can take any shape or configuration that transfers light to sensors **12**,**14**. Light guides **16**,**18** may be configured to have a shape that conforms to an instrument console, to a shape of the display **20**, or to some other shape. Light guides **16**,**18** may be elongated, may be curved, may be an abstract shape, and/or may take some other form. Light guides **16**,**18** would ideally be suited to transfer light from anywhere around the perimeter of display **20** to sensors **12**,**14**, which sensors **12**,**14** may be located on a front side, to the side of, and/or behind the display face of display **20**. But light guides **16**,**18** may only transfer light from more limited areas in some embodiments that include light guides **16**,**18**. Light guides **16**,**18** may be formed from plastic, acrylic or some other material. Light guides **16**,**18** may be comprised of light pipes.

Display **20** may include backlighting which uses a light guide (e.g. light pipe) to distribute light for backlighting. This light guide may also be used to guide light that is reflected by an object approaching display to sensors **12**,**14** (i.e. light guides **16**,**18** might be or comprise the light guide of the back light for the display).

Display **20** may be a single display or may be formed from multiple displays. In one embodiment, display **20** is a single display where the single display imparts the different characteristics to the control regions **21** and the non-control regions **19**. In other embodiments, display **20** may include multiple image generating portions **104** (FIG. **4**) (e.g. projectors) where each image generating portion is separately controlled to generate control regions **21** and/or non-control regions **19**. A single image generator **104** (e.g. projector) may be used to provide displays to multiple surfaces of a screen (or screens) which may appear different to a user. For example, a single projector may provide images to both a primary informational region **20** (FIG. **4**) and to reconfigurable control options (e.g. separate buttons, knobs, etc.) separate from the primary display area **20**.

Display **20** may be a projector type display, may be a panel display (e.g. where the display elements are located proximate to the display surface rather than being projected—such as non projected LCD displays, OLED displays, VF display, etc.), may be a cathode-based display, may use some other type of display, and/or may use a combination of these types of displays. For projector type displays, the display could be a DMD (digital micro-mirror display) or could be any other type of projected display. Panel displays may be flat panel display or may be formed into non-flat shapes such as curved shapes.

Any combination of unique characteristics may be used to identify unique regions **19**,**21**. For example, four control regions **21** may be separately identified by displaying control regions with light modulated at two frequencies (A and B) where the control regions are displayed at two separately identifiable times (1 and 2). This would allow four different frequency/time pairs (A1, A2, B1, and B2) to be established, where each of the four unique pairs could correspond to a unique control region **21**. Also, a third (or more) criteria could also be added (e.g. whether infrared light was also detected) to differentiate the various control or non-control regions. As another example, a single frequency could be used for control regions **21** (to differentiate control regions **21** from non-control regions **19**) and time variation could be used to differentiate between the control regions **21**. See, for example, the embodiment illustrated in FIG. **16**.

Processing circuit **22** may include multiple components that, in some embodiments, may be spread across multiple circuit carrying elements (e.g. PCBs) and whose components may or may not be located in proximity to each other. For example, processing circuit **22** could include an ASIC configured to receive data from sensors **12**, **14** and process the data to output data signifying the frequency at which the light received by sensors **12**, **14** were modulated. Processing circuit **22** could then also include a microprocessor configured to receive the data from the ASIC, determine which (and/or whether a) command was chosen by a user based on the data received from the ASIC, and to control display **20** and/or output command (or other) data to other vehicle systems **28** based on the determination.

Processing circuit **22** can include various types of processing circuitry, digital and/or analog, and may include a microprocessor, microcontroller, application-specific integrated circuit (ASIC), field programmable gate array (FPGA), or other circuitry configured to perform various input/output, control, analysis, and other functions to be described herein. Processing circuit **22** may be configured to digitize data, to filter data, to analyze data, to combine data, to output command signals, and/or to process data in some other manner. Processing circuit **22** may also include a memory that stores data. Processing circuit **22** could be composed of a plurality of separate circuits and discrete circuit elements. In some embodiments, processing circuit **22** will essentially comprise solid state electronic components such as a microprocessor (e.g. microcontroller). Processing circuit **22** may be mounted on a single board in a single location or may be spread throughout multiple locations which cooperate to act as processing circuit **22**, including components connected across a vehicle bus **26**. In some embodiments, processing circuit **22** may be located in a single location and/or all the components of processing circuit **22** will be closely connected.

Processing circuit **22** may be configured to wait for a confidence level prior to affirmatively registering that a control region **21** has been selected. For example, processing circuit **22** may be configured to check to see if a control region **21** has been indicated a selected multiple number of times before executing the command associated with the control region **21**. Processing circuit **22** may be configured to wait until a control region **21** is consistently identified as selected (e.g. over 50% or over 70% or over 90% of the actuations identified by processing circuit **22** indicate that the control region **21** has been selected). Other criteria can also be used to provide confidence that the control region **21** has been purposely selected.

Processing circuit **22** may also be configured to control display **20** to change the manner in which a control region **21** is displayed if processing circuit **22** determines that a user may be approaching the control region **21**. For example, processing circuit **22** may be configured to enlarge an area of display **20** associated with control region **21** if processing circuit **22** determines that a user is approaching the control region **21** (see, e.g. FIGS. **10**-**12**). Enlarging the area of display **20** may allow processing circuit **22** to more accurately register a desired position for the control region **21**. As another example, processing circuit **22** may be configured to change the types of graphics used to indicate the control

region **21** if processing circuit **22** determines that a user is approaching the control region **21** (see, e.g. FIGS. **10** and **12**). Processing circuit **22** could be configured to control display **20** to change any control region **21** in response to a user's approach, some types of control regions **21**, no control regions **21**, the types of control regions **21** pre-selected by a user, etc.

Processing circuit **22** may be configured to provide data (including command signals) to other systems **24**,**28**. For example, processing circuit **22** may be configured to control (and/or may include) a display driver **24** that is configured to control various aspects (mirror position, pixel addressing, light intensity, etc.) of display **20**. For a display system used in a vehicle, processing circuit **22** may be configured to provide data to various other vehicle systems **28**. Processing circuit **22** may provide this information across a vehicle bus **26**, through a direct link **30** (which could include a wireless link such as a Bluetooth link), by having common components (e.g. a common microprocessor) with one or more of the vehicle systems, etc. Processing circuit **22** may also be configured to receive information from the various other vehicle systems **28** such as information to be displayed on display **20**.

Sensors **12**,**14** (particularly in combination with light guides **16**,**18**) may be configured to receive light that is scattered in multiple directions. For example, sensors **12**,**14** may be configured to receive light that is scattered in substantially opposite directions (e.g. scattered in directions whose vectors are separated by at least about 150° or 165° and/or scattered in directions that are separated by at least about 150° or 165° observed from the plane formed by the sensors and/or sensor system—sensors **12**,**14** and light guides **16**,**18**).

According to some embodiments, system **10** may be configured to be able to identify a user actuation of a control region **19** at a distance from the display/graphic surface **102** (FIG. **4**) of display **20**. For example, system **10** may be configured such that it is capable of identifying a user actuation of a control region from a position above the control surface without a user touching the display surface (e.g. at about at least 1 cm, about at least 2 cm, and/or at about at least 3 cm from the display surface). According to some of these embodiments, system **10** may be configured to identify a user actuation of a control region at about 5 cm. System **10** may be configured to take action based on the identification, at one or more of these distances, that a control region has been actuated (e.g. may initiate the action indicated by the control region, may identify the control region as the user's likely target and bring it to the forefront, etc.).

According to some embodiments, an interactive touch-free method for operating curved surfaces, especially image-display screens, may be provided. A certain gap (e.g. 5-10 cm) may be maintained between the operating surface and the operator. For example, system **10** may include a transparent/translucent barrier (e.g. a plastic or acrylic panel) between the display surface **102** (FIG. **4**) and a user of the system. Sensors **12**,**14** may be located behind the barrier, may be located in front of the barrier, or may have some other location.

In a display **20** that uses a mirror-based technology, mirrors which are not reflecting any light to the screen **102** (FIG. **4**) for certain pixels (all parts of the screen which are not 100% white) can be used to reflect the light that is reflected from a finger to a light sensor **12**,**14**. Thus, a lens system of a projector **104** (FIG. **4**) may be configured to perform at least two functions; generating the image and sending light from the reflecting element (the finger) to the light sensor **12**,**14**.

Control regions **21** of display **20** can take any number of forms. Control regions **21** may be displayed as individual buttons, keypads, interactive images (such as interactive images that have nothing in common with "conventional" buttons), etc.

Multiple control regions **21** may be used to implement the control function of a control which is displayed as a single control. For example, the control region **21** may be displayed as a slider, a knob, etc. In this case the image of the control knob may be designed to consist of two or more control regions **21**. The user sees the picture of a singular knob; however, display **20** is displaying and processing circuit **22** is registering two different sensitive control regions **21** within the same "knob." When a user approaches the "control knob," light is reflected onto both regions **21**, but because of the desire to slide the knob, one of the two regions will receive a larger amount. Under the control of processing circuit **22** (e.g. software running on a microprocessor of processing circuit **22**), the control knob can be configured to not slide as long as the two control regions **21** of the knob are receiving roughly equal amounts of reflected light. Thus, the knob may be configured to follow the movement of the finger.

If processing circuit **22** includes a microprocessor, the interior of the vehicle or its design may be determined by software. This software may be updated over time. Also, a user may be allowed to personalize the functions and/or the appearance of the display **20** and/or dashboard of a vehicle. Further, a manufacturer may be able to use a single system to achieve different styles in different vehicle models. The control buttons and functions could also be available and/or reconfigurable over a home network, the Internet, etc.

An exemplary system includes a display as discussed above, wireless headphones (e.g. headphones using light, such as infrared light, or other electromagnetic radiation to wirelessly receive audio data), and/or a wireless remote control (e.g. a wireless remote control configured to use light, such as infrared light, or other electromagnetic radiation to transmit control signals). See, for example, FIGS. **20** and **24**. The transmitters that transmit to the wireless headphones can both transmit the audio data (FM, AM, PSK, FSK, or ASK modulated data) to the wireless headphone and serve as the source of the characteristic of reflected light for identifying user actuations of control regions **21** displayed on the display **20**. The receiver (e.g. sensor) used to receive commands from the wireless remote control can be configured to receive both the reflected light for identifying user actuation of control regions **21**, and the signals transmitted by the remote control. The processing circuit **22** may be configured to receive data from the receiver (e.g. sensor), process the receiver information to derive data representative of a control region **21** to be actuated (e.g. using any of the techniques disclosed above), identify whether control regions **21** of a display **20** have been actuated (e.g. using any of the techniques described above), identify data as received from the remote control, provide the remote control data and/or the control region **21** data to another system, and/or execute the commands contained in the data from the remote control or indicated by the control region **21** actuated. In some embodiments, data processed by the processing circuit may be transmitted to another device for further processing (e.g. execution of commands).

Correction for Ambient Lighting

Referring to FIGS. **8** and **9**, an arrangement for measuring reflected light may have a wide dynamic range and/or be insensitive to ambient light.

U.S. Pat. No. 5,666,037 describes a process that can react sensitively to light without responding to the conventional forms of interference such as ambient light. In this system, a second transmitting element, potentially emitting directly into the sensors **12**,**14** (e.g. a photodiode), is used during the

transmission pauses of the outward-transmitting element to correct the power received by the photodiode in such a way that only a direct light signal without any clock-synchronizing signal components is present at the sensors **12**,**14**. In this system, it is not the received signal that is measured; instead, the power of the second LED, which corresponds to power received by the sensors **12**,**14**, is used to evaluate the signals.

Referring to FIG. **8**, a diagram shows how the light signal received from the screen can be corrected by a light-emitting diode to form a "0" signal. Section A corresponds to a brightness signal with high luminous density, and section B to a signal of moderate luminous density. Section C corresponds to a moderate luminous intensity signal but at a much higher clock rate. Sections A, B, C do not have to be generated sequentially; it would also be possible to generate them in parallel.

Signal E shows first a signal of the type that would be present at the output of the photodiode amplifier without correction. D shows the synchronous demodulator clock signal, and F shows the correction value required to correct the signal in the photodiode to "0". The associated control power for the light-emitting diode is shown in G. Signal G is obtained only when there is a reflection from the screen or from a finger. The output signal of the photodiode amplifier possibly contains only the noise of the diode and of the amplifier and no synchronizing clock components. This is shown as signal H.

Referring to FIG. **9**, a block diagram of the circuit of FIG. **8** for correcting a sensor includes a photodiode **12** that detects the signal reflected from the finger **270**. This photodiode **12** can be located behind or next to the screen **102**, but in any case it must be able to receive the signal **268** reflected from the finger **270**. The amplified signal is sent via the preamp **202** to the synchronous demodulator **204**, which breaks the photodiode signal down again into its two components, namely, the projection power and LED power. These are compared in the comparator **204***b*. If there is a difference between the two values, the power of the LED **206** is adjusted until the signal received by the photodiode **12** no longer contains any synchronizing clock components. The control signal is tapped at **208** for further processing. A clock circuit **210** drives the LED power control unit **212**, the synchronous demodulator, and the projector control unit **214**.

In the projector control unit **214**, the image data **216** are linked with the keypad data **218** so that the projector can be actuated accordingly.

A circuit design of this type can provide high sensitivity, which means that the photodiode **12** may be installed near the projector **104**. Instead of the one light source (LED **206**), it would also be possible, of course, to connect multiple light sources such as two or three light sources (LEDs) emitting the similar (e.g. the same) colors as those of the projector **104** (e.g. R, G, B) in synchrony with the color transmission of the projector **104** in such a way that each individual color can be compensated with its own wavelength. Particularly in embodiments where the sensor **12** is covered in such a way that ambient lighting is reduced, a single light source **206** (e.g. an LED with the color "white") may be sufficient.

A sensor **12** (e.g. photodiode **206**) that is positioned near the projector may also pick up light sent from the projector **104** to the screen **102**. This may be seen by sensor **12** (FIG. **1**) with an intensity that is many times greater than that of the light **268** reflected by a finger **270**. However, this is a static value; a dynamic change occurs when the reflection changes (e.g., when a hand **270** approaches the screen **102**). Dynamic value changes equivalent to one-thousandth of the static reflection may be detected without being affected by ambient light by means of, for example, the process known as "Halios" (High Ambient Light Independent Optical System) (See U.S. Pat. No. 5,666,037 and PCT application WO 95/01561).

Measuring and/or Displaying Shadows

In some embodiments, sensors **12**,**14** and/or processing circuit **22** may be configured to measure the direction from which sunlight/ambient light is falling on the vehicle (particularly on display **20**). Sensors **12**,**14** may be arranged such that they can be used to determine the direction in which the incident light is falling on the display surface **102**.

Based on a determination of the direction from which the ambient light is shining, processing circuit **22** can be configured to create a shadowing effect. As shown in FIG. **13**, ambient (sun) light **260** is coming from the left so processing circuit **22** (FIG. **1**) causes artificial shadows **264** to be displayed down and to the right of display elements **268**. As shown in FIG. **14**, as the direction of the ambient light **260** changes (e.g. as a vehicle changes direction, as the direction of light sources change, as the time of day changes, etc.) the direction of artificial shadows **264** may change.

The light sensors **12**,**14** used to measure direction and intensity of ambient light can be located around and at a slight angle to screen **102** (FIG. **4**). The sensors **12**,**14** can be used simultaneously as receivers for the display control system **10**, described above. The sensors **12**,**14** configured to gather information relating to the direction and intensity of the ambient light could also be installed behind the screen.

By creating artificial shadows, a more realistic 3D feel can be imparted to display **20** in some embodiments that implement the artificial shadows.

If complete accuracy is not as important, a similar artificial shadowing effect may be achieved by combining information from a compass system (or other direction information providing system such as a GPS system) and time/date information.

Display Systems

Processing circuit **22** may be configured to send control data to other vehicle systems **28** in response to receiving a user command entered by actuating a control region **21**. The other vehicle system **28** may include a GPS system, an HVAC system, an entertainment system, a trip computer, an audio system, a camera system, a phone system, a compass system, an e-mail system, a vehicle lighting system, and/or some other vehicle system. Processing circuit **22** may also be configured to receive data from these other vehicle systems **28** (e.g. data to display, possible control regions to display, etc.). Other vehicle system **28** and processing circuit **22** may be entirely separate, may share some components, may be essentially integral, or may maintain another relationship.

Display **20** may be configured to display information (controls, data, etc.) for various systems. This information may include GPS information, HVAC information, entertainment information which includes rear seat entertainment controls, trip computer information, audio system information including radio information such as satellite radio information, camera information which may include rear-seat camera information and may include back-up camera information, may include phone system information, may include compass information, may include e-mail information, may include task information, may include CD information, may include electronic music (e.g. MP3 player) information, may include vehicle lighting information, and/or may include any number of other types of information. It is contemplated that display **20** may be configured to display one, two, multiple, or none of the possible combinations of these types of information.

EXAMPLES

Example 1

As an exemplary implementation of a change in a control region based on a determination that a user may be approaching the control region **21**, a volume control might enlarge or change its graphical representation based on a determination that a user has approached the volume control. As shown in FIG. **10**, a volume control **302** is an original first size when operating in normal conditions.

As shown in FIG. **11**, when a finger approaches the volume control region **302**, processing circuit **22** may be configured to expand this control region **302** to fill the entire screen.

As shown in FIG. **12**, when a user's finger approaches control region **302**, processing circuit **22** (FIG. **1**) is configured to transform this volume control region **302** by enlarging the control region **302** and by changing the graphical representation of the volume control region **302**. Processing circuit **302** transforms volume control region **302** into a large slide controller.

The brightness of the individual pixels can be adjusted by varying the pulse-pause ratios while the frequency in the area of the control region remains the same. Both completely black and completely white pixels can also be generated when surfaces of moderate brightness are located in their immediate vicinity. Thus it is possible to make a graphic display into an interactive surface.

Example 2

Referring to FIG. **15**, one exemplary display **20** is illustrated. The dashboard of a vehicle in which display **20** is installed may have a smooth, curved surface with few or no mechanical control elements. Typical functions such as the radio **402**, air-conditioner **404**, etc., may be projected as images onto the graphic surface **102** (FIG. **4**) of display **20** under control of a processing circuit **22** (FIG. **1**). The images **402**,**404** may be photorealistic with interactive/movable shadows.

If a user wants to operate a radio **28** (FIG. **1**) of the vehicle, the display **20** in the vehicle shows several functions **406-414** similar to standard radio controls. The images **406-414** may have the appearance of menu blocks, or, as shown in FIG. **15**, may have the appearance of physical controls such as knobs, buttons, etc.

As a user approaches the radio control area **402** of the display **20** (e.g. by the time the user is within 50 or 30 mm of display screen **102**), processing circuit **22** (FIG. **1**) may be configured to enlarge the radio control region **402**, and may be configured to hide the non-radio control region (e.g. HVAC controls **404**).

When approached, the standard volume knob **408** may be changed into a linear controller that occupies a larger area (see, e.g., FIGS. **10-12**). A larger control area may make it easier to operate the volume control region **408** in less than ideal conditions, such as on bumpy roads.

With reference to FIG. **12**, users may "move" the slider **304** by moving their hand to adjust the volume and thus increase or decrease the volume to the desired level.

It is also possible that the linear controller **304** could appear in the upper part of the screen, while underneath a view of the passenger compartment of the vehicle appears with a circle to indicate the setting selected for the acoustic balance within the vehicle. By "grabbing" and moving the balance circle, the user can then adjust the position of the acoustic center point in space.

After making the desired changes and pulling his hand away (e.g. to at least 50, 100 or 150 mm from the display screen **102**) the display **20** may revert to its original condition.

Illustrative Embodiments

One embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a control region, a point light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a control region, a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, a light guide configured to guide light reflected from the display to the light sensor, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a control region, a light sensor located in front of the graphic surface of the display and configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a control region that is configured to be displayed at a different frequency than other portions of the displayed information, a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The system includes a display configured to display information to a user, the displayed information including a control region, a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated based on a characteristic of the light received.

In some of these embodiments, the characteristic may be a frequency at which the light is modulated.

In some of these embodiments, the characteristic is a time at which the light is received by the sensor. The display may be configured to display different portions of the displayed information at different times. The processing circuit may be configured to receive timing data indicative of a time at which the control region was displayed by the display. The processing circuit may be configured to determine whether the control region has been actuated based on the time at which the

light was received by the sensor, and the timing data indicative of the time at which the control region was displayed.

In some of these embodiments, the characteristic may include an amplitude of the light.

Another embodiment is directed to a control system. The control system includes a panel display configured to display information to a user, the displayed information including a control region; a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light; and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a plurality of control regions that are differentiated from each other based on a characteristic, and a processing circuit configured to determine which control region has been actuated based on the characteristic that differentiates each control region. The characteristic includes at least one of a frequency of light displaying each control region, a phase of light displaying each control region, an amplitude of light displaying each control region, and timing of light displaying each control region.

Another embodiment is directed to a method for determining that a control region of a display has been actuated. The method comprises displaying a control region having a predetermined characteristic, receiving data based on reflections as a user approaches the control region, measuring the received data for the predetermined characteristic, analyzing the measurement to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user, the displayed information including a control region, a light sensor configured to receive light as it is reflected by a finger approaching the control region while the finger is an inch away from a display surface of the display, and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The system includes a display configured to display information to a user, the displayed information including a control region; a light sensor system configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, the light sensor system capable of receiving light that has been scattered in substantially opposite directions, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The control system also includes at least two light sensors configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit that receives the data output from the light sensors, and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light. The light sensor is not a machine vision sensor. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light. The light sensor is not a camera. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Another embodiment is direct to a display system. The display system includes a display configured to display information to a user, and a processing circuit configured to receive the data indicative of an angle of incident light and configured to control display of moving artificial shadows based on the data.

Another embodiment is directed to a vehicle control system. The system includes a light sensor configured to receive light as it is reflected by an object, a projector-based display configured to display information to a user, and a processing circuit coupled to the light sensor. The displayed information includes a control region. The projector based display includes a mirror configured to reflect light to a display surface to form a pixel of the displayed information, and is also configured to reflect light to the light sensor. The processing circuit is configured to receive the data output from the light sensor, and to control at least one vehicle system based on the data received from the light sensor.

In any of the above-mentioned embodiments, the display may include reconfigurable controls. The reconfigurable controls may be two dimensionally represented controls. The reconfigurable controls may be tactile controls. The tactile controls may be include at least one of a button, a slider, and a knob. The light sensor may be configured to detect light from the reconfigurable display that is reflected by an object.

In any of the above-mentioned embodiments, the display may be mounted in a vehicle and may be configured to display information from at least one other vehicle system. In some embodiments, the other vehicle system may include at least one of a GPS system, an HVAC system, an entertainment system, a trip computer, an audio system, a camera system, a phone system, a compass system, an e-mail system, and a vehicle lighting system. The at least one other vehicle system may include a multiplicity of systems including at least two of those mentioned above.

In any of the above-mentioned embodiments, the processing circuit may be configured to determine that the control region has been actuated only after a series of determinations based on received data consistently indicate that the control region has been actuated.

In any of the above-mentioned embodiments, a display surface of the display may be non-flat.

In any of the above-mentioned embodiments, the system may further include a controllable light source separate from the display that is configured to provide light to the light sensor. The controllable light source may be configured to aid in correcting effects of ambient light on the sensor. The system may include two or more such light sources configured to provide light to the display. The controllable light sources may have colors similar to colors of the display.

In any of the above-mentioned embodiments, the display may include a projector configured to project an image onto a display surface.

In any of the above-mentioned embodiments, the processing circuit may be configured such that it can determine that a control region has been actuated without a user touching a display surface of the display.

In any of the above-mentioned embodiments, the display may be configured such that a control region can change based on a determination that an object is approaching the control region.

In any of the above-mentioned embodiments, the light sensor may be configured to gather data representative of an angle of ambient light.

In any of the above-mentioned embodiments, the processing circuit may be configured to receive data indicative of an angle of incident light. The processing circuit may be configured to display moving artificial shadows on the display based on the angle of incident light.

One embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes at least one control region. The system also includes a point light sensor configured to receive light as it is reflected by an object approaching the one or more control regions and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, a light guide configured to guide light reflected from the display to the light sensor, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor located in front of the graphic surface of the display and configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether a control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region that is configured to be displayed using light that is modulated at a different frequency than other portions of the displayed information. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated based on a characteristic of the light received.

In some of these embodiments, the characteristic may be a frequency at which the light is modulated.

In some of these embodiments, the characteristic is a time at which the light is received by the sensor. The display may be configured to display different portions of the displayed information at different times. The processing circuit may be configured to receive timing data indicative of a time at which the control region was displayed by the display. The processing circuit may be configured to determine whether the control region has been actuated based on the time at which the light was received by the sensor, and the timing data indicative of the time at which the control region was displayed.

In some of these embodiments, the characteristic may include an amplitude of some portion of and/or all of the light.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light; and a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a plurality of control regions that are differentiated from each other based on a characteristic. The system also includes a processing circuit configured to determine which control region has been actuated based on the characteristic that differentiates each control region. The characteristic may include one or more of a modulated frequency of light displaying each control region, a phase of light displaying each control region, an amplitude of light displaying each control region, a color of each control region, and timing of light displaying each control region.

Another embodiment is directed to a method for determining that a control region of a display has been actuated. The method comprises displaying a control region having a predetermined characteristic, receiving data based on reflections as a user approaches the control region, measuring the received data for the predetermined characteristic, analyzing the measurement to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by a finger approaching the control region (e.g. where the finger is an inch away from a display surface of the display), and to output data in response to the received light. The system further includes a processing circuit configured to receive the data output from the light sensor and to process the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor system configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit configured to receive

the data output from the light sensor and to process the received data to determine whether the control region has been actuated. The light sensor system is capable of receiving light that has been scattered in substantially opposite directions.

Another embodiment is directed to a vehicle control system. The system includes a light sensor configured to receive light as it is reflected by an object, a projector-based display configured to display information to a user, and a processing circuit coupled to the light sensor. The displayed information includes a control region. The projector based display may include a mirror configured to reflect light to a display surface to form a pixel of the displayed information, and is also configured to reflect light to the light sensor. The processing circuit is configured to receive the data output from the light sensor, and to control at least one vehicle system based on the data received from the light sensor. The projector based display may also include one or more of an LCD display, a LASER scanning device, etc.

Another embodiment is direct to a display system. The display system includes a display configured to display information to a user, and a processing circuit configured to receive the data indicative of an angle of incident light and configured to control display of moving artificial shadows based on the data.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The control system also includes at least two light sensors configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light, and a processing circuit that receives the data output from the light sensors, and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light. The light sensor is not a machine vision sensor. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system also includes a light sensor configured to receive light as it is reflected by an object approaching the control region and to output data in response to the received light. The light sensor is not a camera. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The display includes a backlight that can be modulated. The system also includes a light sensor configured to receive the modulated light as it is reflected by an object approaching the control region and to output data in response to the received light. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a plurality of control regions. The display includes a backlight that can be modulated. The system also includes a light sensor configured to receive the modulated light as it is reflected by an object approaching a control region and to output data in response to the received light. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether a control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The display includes a backlight that can be modulated. The system also includes at least two light sensors configured to receive the modulated light as it is reflected by an object approaching the control region and to output data in response to the received light. The system also includes a processing circuit that receives the data output from the light sensors and processes the received data to determine whether the control region has been actuated.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system includes a remote control that utilizes light to transmit information. The system also includes a light sensor configured to receive the light as it is reflected by an object approaching the control region or transmitted by the remote control and to output data in response to the received light. The system also includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated or transmits the received data to another processing circuit.

Another embodiment is directed to a control system. The control system includes a display configured to display information to a user. The displayed information includes a control region. The system includes an audio transmission system that utilizes light to transmit information. The system also includes a light sensor configured to receive the light as it is reflected by an object approaching the control region and to output data in response to the received light. The system further includes a processing circuit that receives the data output from the light sensor and processes the received data to determine whether the control region has been actuated.

Many embodiments can be used with, in addition to standard displays, displays whose display surface is not flat.

Other features may be gleaned from the disclosure, including the examples and Summary. Some embodiments will be combinations of any of the embodiments discussed above with each other (and all such possible combinations are contemplated) and/or with any of the additional features discussed herein.

The various features of the illustrative embodiments are a list of some, although not all, potential embodiments evident in the description. The various features described above in the detailed description and illustrative embodiments can be used in any combination with other features from other parts of the description and illustrative embodiments. Each such possible combination is contemplated.

While illustrated in a vehicle as one exemplary implementation, the systems described above can also be applied in non-vehicle systems. For example, the display and control systems discussed above could be used as inputs to a touch screen device of a computer, including hand-held computing devices. As another example, the display and control systems

could be used in a kiosk with reconfigurable controls. While other vehicle systems **28** are illustrated in FIG. **1**, it is evident that in non-vehicle systems the "other systems" would be other non-display systems such as memory holding information to be displayed, a central server (e.g. in a banking application), etc.

Also, while much of the discussion has been directed to light, similar principles can be directed to systems that provide a form of radiation (e.g. electromagnetic radiation) other than light that can be reflected by a user and/or by an object used by the user to input commands.

It is also possible to use an arrangement similar to that described in the embodiments above that does not use light as the means of differentiation for the control regions.

What is claimed is:

1. A control system comprising:

a display configured to display information to a user, the displayed information including a control region and a non-control region;

a light sensor configured to receive light as it is reflected by an object approaching the control region or the non-control region and to output a signal in response to the received light; and

a processing circuit configured to

receive a signal based on the signal output from the light sensor,

differentiate between the control region and the non-control region,

determine whether the object is approaching the control region or the non-control region,

process the received signal to determine whether the control region has been actuated based on a characteristic of the light received by the light sensor, and

record a time at which the light sensor receives the reflected light and compare the recorded time to a time at which pixels corresponding to the control region are illuminated.

2. The control system of claim **1**, wherein the display is configured to provide the light containing the characteristic.

3. The control system of claim **2**, wherein the display is configured to provide light containing the characteristic to contain a set of one or more characteristics unique to a specific control region displayed by the display.

4. The control system of claim **2**, wherein the light containing the characteristic is configured to be provided by a light source used to illuminate areas in addition to the control region such that the light containing the characteristic can be reflected by an object approaching a region of the display other than the control region.

5. The control system of claim **1**, wherein the system is configured such that light containing the characteristic is provided from behind a display surface of the display.

6. The control system of claim **1**, wherein the characteristic of light corresponds to a location on a display surface of the display from which the light was provided.

7. The control system of claim **1**, wherein,

the control system further comprises a light source;

the light source is configured to provide a light which can be reflected by a user approaching a control region to actuate the control region;

the light sensor is configured to receive the light reflected from the light source and to provide an output signal based on the reflected light from the light source received by the light sensor;

the processing circuit is configured to determine whether the control region has been actuated based on the signal output from the light sensor in response to the reflected light from the light source received by the processing circuit; and

the light source is configured to provide a data output configured to wirelessly provide data to a system that is remote from the light source.

8. The control system of claim **7**, wherein the light source is configured to provide an output carrying an audio signal.

9. The control system of claim **1**, wherein the display is configured to modulate light at different frequencies, and the processing circuit is configured to determine which control region has been actuated based on the frequency at which the received light has been modulated.

10. The control system of claim **1**, wherein a plurality of backlights of the display are configured to provide light containing different characteristics, and wherein the processing circuit is configured to determine whether the control region has been actuated based on the different characteristics of the light received.

11. The control system of claim **1**, wherein the light sensor is further configured to receive a signal from a remote control and is configured to provide an output signal based on the signal from the remote control such that commands transmitted by the remote control can be executed.

12. The control system of claim **1**, further comprising a light guide configured to guide light to the light sensor.

13. The control system of claim **12**, wherein the light guide is configured to be located at least in front of the display surface of the display.

14. The control system of claim **13**, wherein the light sensor is configured to be located behind the display surface of the display.

15. The control system of claim **12**, wherein the light guide is configured to be located to at least one side of a display surface of the display.

16. The control system of claim **12**, wherein the light guide is configured to be located around multiple sides of the display surface of the display.

17. The control system of claim **12**, wherein the light guide is further configured to guide light used to illuminate the display.

18. The control system of claim **1**, wherein,

the light sensor is a first light sensor;

the control system further comprises a second light sensor separate from the first light sensor, the second light sensor configured to receive light as it is reflected by an object approaching the control region and to output a signal in response to the received light; and

the processing circuit is further configured to receive a signal based on the signal output from the second light sensor and to process the received signal based on the signal output from the second light sensor to determine whether the control region has been actuated.

19. The control system of claim **18**, wherein the first light sensor and second light sensor are configured such that they can both receive light reflected from a common light source.

20. The control system of claim **1**, wherein the light sensor is a sensor comprising no more than 25 pixels.

21. The control system of claim **20**, wherein the light sensor is a point light sensor.

22. The control system of claim **1**, wherein the system is configured such that light received by the light sensor is collected from in front of a display surface of the display.

23. The control system of claim **1**, wherein the control region to be actuated can be identified without touching the display.

24. The control system of claim 1, wherein the system is configured to detect light that has been reflected in multiple directions.

25. The control system of claim 24, wherein the multiple directions include at least two directions that are substantially opposite directions with respect to a display surface of the display.

26. The control system of claim 24, wherein the light sensor is configured to receive the light reflected in multiple directions.

27. The control system of claim 1, wherein the display comprises a curved display surface.

28. The control system of claim 1, wherein processing of the received signal by the processing circuit comprises processing data based on the signal received from the light sensor.

29. The control system of claim 28, wherein the processing circuit is configured to receive the data based on the signal output from the light sensor from a vehicle bus.

30. The control system of claim 1, wherein the processing circuit is directly connected to the light sensor such that the output signal that is output by the light sensor is the same as the received signal that is received by the processing circuit based on the output signal.

31. The control system of claim 1, wherein the display comprises an LCD display.

32. The control system of claim 1, wherein the processing circuit comprises an IC containing the light sensor.

33. The control system of claim 1, wherein the processing circuit is configured to:

differentiate between the control region and the non-control region based on a color associated with each of the control region and the non-control region, and

determine, based on the color associated with each of the control region and the non-control region, whether the object is approaching the control region or the non-control region.

34. A control system comprising:

a display configured to display information to a user, the displayed information including a control region and a non-control region;

a light sensor configured to receive light as it is reflected by an object approaching the control region or the non-control region and to provide an output signal in response to the received light; and

a processing circuit configured to

receive data based on the signal output from the light sensor in response to the received light,

differentiate between the control region and the non-control region,

determine whether the object is approaching the control region or the non-control region,

process the received signal to determine whether the control region has been actuated; and

record a time at which the light sensor receives the reflected light and compare the recorded time to a time at which pixels corresponding to the control region are illuminated;

wherein the light sensor is further configured to receive a signal from a remote control and is configured to provide an output signal based on the signal from the remote control such that commands transmitted by the remote control can be executed.

35. The control system of claim 34, wherein,

the control system further comprises a light source;

the light source is configured to provide a light which can be reflected by a user approaching a control region to actuate the control region;

the light sensor is configured to receive the light reflected from the light source and to provide an output signal based on the reflected light from the light source received by the light sensor;

the processing circuit is configured to determine whether the control region has been actuated based on the signal output from the light sensor in response to the reflected light from the light source received by the processing circuit; and

the light source is configured to provide a data output configured to wirelessly provide data to a system that is remote from the light source.

36. The control system of claim 34, wherein the processing circuit is configured to:

differentiate between the control region and the non-control region based on a color associated with each of the control region and the non-control region, and

determine, based on the color associated with each of the control region and the non-control region, whether the object is approaching the control region or the non-control region.

37. A control system comprising:

a display configured to display information to a user, the displayed information including a control region and a non-control region;

a light source;

a light sensor configured to receive light from the light source as it is reflected by an object approaching the control region or the non-control region and to provide an output signal in response to the received light; and

a processing circuit configured to

differentiate between the control region and the non-control region,

determine whether the object is approaching the control region or the non-control region,

determine whether the control region has been actuated based on the signal output from the light sensor in response to the reflected light from the light source received by the light sensor; and

record a time at which the light sensor receives the reflected light and compare the recorded time to a time at which pixels corresponding to the control region are illuminated;

wherein the light source is further configured to provide a data output configured to wirelessly provide data to a system that is remote from the light source.

38. The control system of claim 37, wherein the light source is located behind a display surface of the display.

39. The control system of claim 37, wherein the control system comprises a plurality of light sources,

wherein the light sensor is configured to receive light from any of the plurality of light sources.

40. The control system of claim 39, wherein the processing circuit is configured to determine whether the control region has been actuated based on one or more signals output from the light sensor in response to the reflected light from at least two of the plurality of light sources.

41. The control system of claim 37, wherein the data output by the light source comprises an audio signal.

42. The system of claim 37, wherein the display comprises reconfigurable controls.

43. The system of claim 37, wherein the display is mounted in a vehicle and is configured to display information from at least one other vehicle system.

44. The system of claim **37**, wherein the processing circuit is configured to determine that the control region has been actuated only after a series of determinations based on received data consistently indicate that the control region has been actuated.

45. A display system comprising:

a display configured to display information to a user; and

a processing circuit configured to

receive data indicative of an angle of incident light and create moving artificial shadows based on the data, and

record a time at which a light sensor receives light reflected by an object approaching the display and compare the recorded time to a time at which pixels corresponding to a control region of the display are illuminated.

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